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TECHNICAL ORDER NO. 02-35GC-2

HANDBOOK OF

SERVICE INSTRUCTIONS

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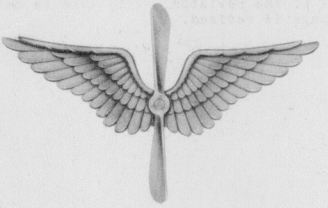
R-1820-65, -71, -73, -87 and -97 AIRCRAFT ENGINES



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PUBLISHED BY AUTHORITY OF THE COMMANDING GENERAL, ARMY AIR FORCES, BY THE HEADQUARTERS, FIELD SERVICES, AIR SERVICE COMMAND, PATTERSON FIELD, FAIRFIELD, OHIO

FEDERAL LITHO. CO., DETROIT, MICH.
FEB. 1, 1943 8M

MARCH 10, 1942
REVISED 12-10-42

63

Index of revision pages issued.

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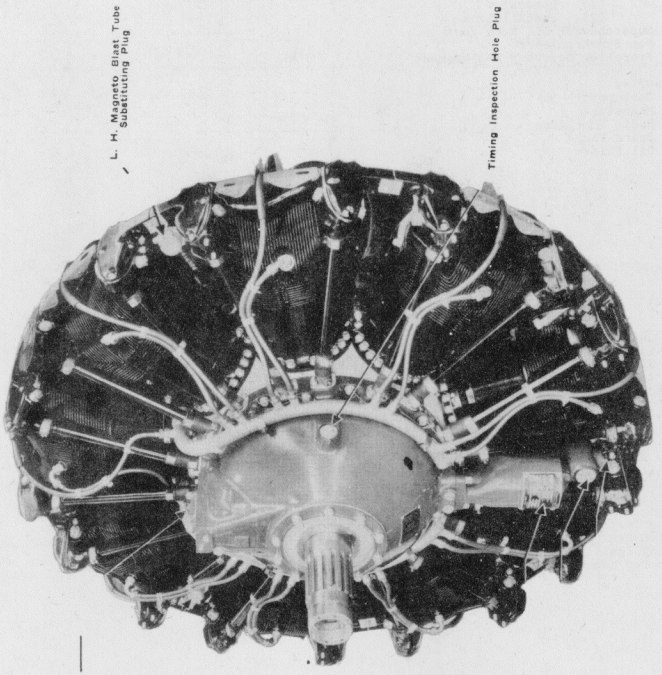
L. H. Magneto Blast Tube Substituting Plug
Timing Inspection Hole Plug
Governor Pump Mount Pad
R. H. Magneto Blast Tube Substituting Plug
Engine Data Plate
Screened Drain Plug
Magnetic Drain Plug

FIG. 1 - THREE QUARTER LEFT FRONT VIEW - R-1820-65 ENGINE

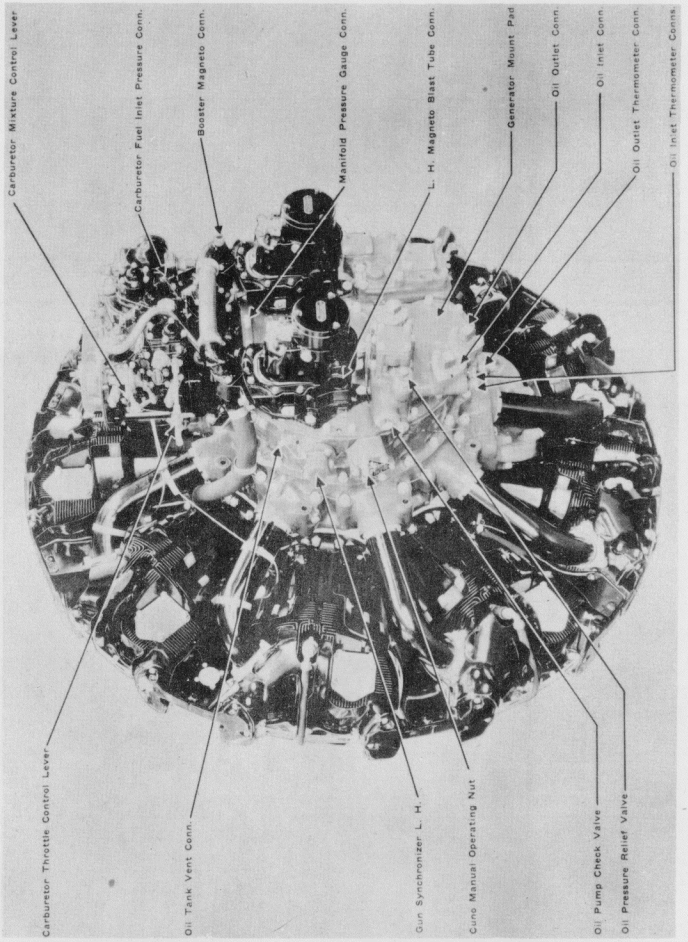

FIG. 2 - THREE QUARTER LEFT REAR VIEW - R-1820-65 ENGINE

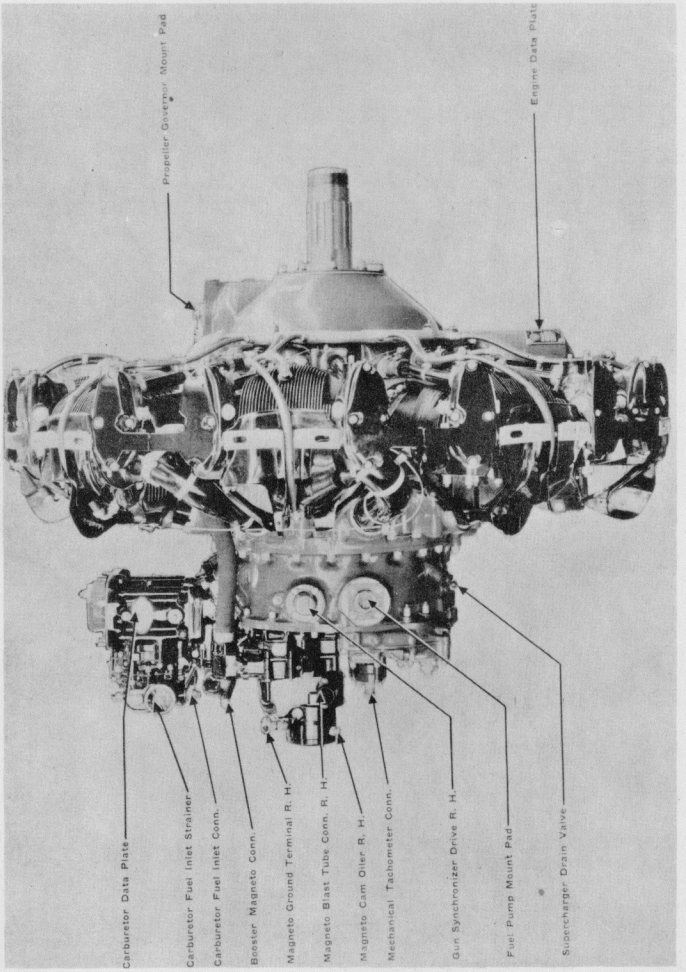
Propeller Governor Mount Pad
Engine Data Plate
Carburetor Data Plate
Carburetor Fuel Inlet Strainer
Carburetor Fuel Inlet Conn.
Booster Magneto Conn.
Magneto Ground Terminal R. H.
Magneto Blast Tube Conn. R. H.
Magneto Cam Oiler R. H.
Mechanical Tachometer Conn.
Gun Synchronizer Drive R. H.
Fuel Pump Mount Pad
Supercharger Drain Valve

FIG. 3 - RIGHT SIDE VIEW - R-1820-65 ENGINE

SECTION I

INTRODUCTION

1. This Technical Order is the Service Instructions of the Models R-1820-65, -71, -73, -87, and -97 engines, manufactured by Wright Aeronautical Corp., Paterson, N. J. Personnel who are required to service and maintain this equipment will read and be familiar also with the information contained in T. O. No. 02-35GC-1 which forms a part of the complete Service Instructions.

2. In this Technical Order, the following definitions will be used:

a. The "Front" of the engine refers to the propeller end.

b. The "Rear" of the engine refers to the anti-propeller end.

c. The "Right" and "Left" sides of the engine refer to the viewpoint of an observer facing the anti-propeller end of the engine.

d. The rotation of the crankshaft and propeller is clockwise as viewed from the anti-propeller end of the engine.

e. The terms "Clockwise" and "Counterclockwise", in respect to accessories, refer to the viewpoint of an observer facing the accessory drive.

f. The cylinders are numbered consecutively in the direction of rotation of the crankshaft, i.e., clockwise as viewed from the anti-propeller end of the engine, beginning with the top cylinder which is designated as Cylinder No. 1.

g. The "Horizontal Position" refers to the position of the engine in level flight.

3. Limits (clearances, fits, etc.) applicable to the Models R-1820-65, -71, -73 and -87 engines are compiled in T. O. No. 02-35-1.

4. Necessary tools for accomplishing the work outlined herein will be found listed in the Service Tools Catalog, T. O. No. 02-35-2, or the Overhaul Tools Catalog, T. O. No. 02-35-3.

5. Reference should be make to the Parts Catalog, T. O. No. 02-35GC-4, for illustrations showing the construction of the various units of these engines.

6. Reference has been made in this Handbook to the following Technical Orders which contain applicable data and instructions:

T. O. No.	
00-1	Index of Technical Instructions and Information
00-20A	The Visual Inspection System for Airplanes
01-1-1	Cleaning of Aeronautical Equipment
02-1-1	Preparation of Engines for Storage
02-1-4	Block, Installation and Flight Tests
02-1-6	Periodic Inspection and Adjustment of Valve Mechanisms
02-1-9	Soldering Shielded Ignition Manifolds
02-1-10	Use of Locknuts
02-1-14	Equipment Comprising "Complete Aircraft Engines"
02-1-24	Cuno Oil Filters
02-1-28	Inspection and Tightening of Intake Pipe Packing Nuts
02-1-29	Ground Operation Instructions for Aircraft Engines
02-1-34	Tightening Crankshaft and Propeller Shaft Thrust Bearing Nuts
02-1-55	Tightening of Cylinder Hold-down Nuts-Air Cooled Radial Engines
02-35-1	Table of Limits - Wright Engines
02-35-2	Service Tools Catalog - Wright Engines
02-35-3	Overhaul Tools Catalog - Wright Engines
02-35-6	Installation and Clearance of Valve Spring Upper Washers Deleted by revision dated 12-10-42.
02-35GC-1	Operation and Flight Instructions - Wright R-1820-65 Engine and Associated Models
02-35GC-3	Overhaul Instructions - Wright R-1820-65 and Associated Models
02-35GC-4	Parts Catalog - R-1820-65 Engine and Associated Models
03-5DA-2	Service Instructions for Aircraft Magnetos (Scintilla)
03-5E-1	Spark Plugs - Use and Reconditioning
03-10BA-2	Service Instructions - Injection Carburetors
03-20CA-2	Service and Overhaul Instructions for Propeller Governors
05-40-10	Cold Weather Operation of Oil Pressure Gages
06-10-1	Aircraft Engine Lubricating Oil, Grades and Use
08-5-1	Shielding and Bonding of Aircraft Deleted by revision dated 12-10-42.

NOTE: Refer to Index, T. O. No. 00-1, for Technical Orders containing additional and supplementary instructions to those given in this Handbook.

SECTION II

TABLES OF SPECIFICATIONS

Models R-1820-65 and R-1820-97

Model	R-1820-65 and -97
Type	Single Row, Static Radial, Air Cooled
Number of Cylinders	9
Bore	6.125"
Stroke	6.875"
Piston Displacement	1823 Cu. In.
Compression Ratio	6.70:1
Blower Gear Ratio	7.00:1
Blower Diameter	11.0"
Rated Speed, in RPM	2300
Rated BHP/RPM at Sea Level	1000/2300
Rated BHP/RPM at Altitude (25,000 Ft.)	1000/2300
Take-Off BHP/RPM	1200/2500
Rotation of Crankshaft (From Anti-propeller End)	Clockwise
Rotation of Propeller (From Anti-propeller End)	Clockwise
Propeller Reduction Gear Ratio: R-1820-65 and -97	.5625 (16:9)
Propeller Shaft Spline Size	S.A.E. No. 50
Average Weight of Engine	1308#
Overall Length of Engine	48.22"
Position of Center of Gravity:	
Distance aft of Thrust Nut Front Face	14.76"
Distance forward of Rear Face of Mounting Bosses	7.38"
Distance above Centerline of Crankshaft	0.26"
Diameter of Mounting Bolt Circle	23.37"
Number of Mounting Bolts	9
Overall Diameter of Engine	55 1/8"

IGNITION

Magneto Type	Scintilla SF9L4
Rotation of Magneto Drive (From Anti-propeller End)	Clockwise
Magneto Drive Shaft Speed Ratio to Crankshaft	1.125
Spark Plug Gap	.012"
Spark Plug Type	Champion C34S or Aero LS38C
Spark Timing on No. 1 Cylinder	
Left Magneto (Rear Plugs) - Degree B.T.C.	20°
Right Magneto (Front Plugs) - Degree B.T.C.	20°

VALVES AND TIMING

Intake Opens - Degree B.T.C.	15°
Intake Closes - Degree A.B.C.	44°
Exhaust Opens - Degree B.B.C.	74°
Exhaust Closes - Degree A.T.C.	25°
Intake Remains Open, Crankshaft Degrees	239°
Exhaust Remains Open, Crankshaft Degrees	279°
Valve Lift	.562"
Valve Rocker Clearance - Cold	.010"
Timing Clearance	.075"

Deleted by revision dated 12-10-42.

FUEL SYSTEM

Carburetor Type	Bendix Stromberg Injection PD12H2
Fuel:	
Specification	AN-VV-F-781
Octane	100
Fuel Inlet Connection - Thread	.750 Std. Pipe Tap
Supercharger Drain Valve Connection - Thread	.250 Std. Pipe Tap
Priming System Inlet Connection - Thread	.125 Std. Pipe Tap

Deleted by revision dated 12-10-42.

Models R-1820-65 and R-1820-97

LUBRICATION SYSTEM

Grade of Oil Desired in Flight - Specification	AN-VV-O-446
Oil Pump Drive Shaft Speed Ratio to Crankshaft	1.125:1
Rotation of Oil Pump Drive Shaft (Facing Drive)	Counterclockwise
Oil Pump Inlet Flange Connection - Thread	1"
Oil Pump Outlet Flange Connection - Thread	.750"
Oil Tank Vent Connection - Thread	.750"

ACCESSORY DRIVES

Dual Accessory Drive:	
Upper Mount	Four .250" - 28 U.S.F. Studs .78" High Spaced 1.875" x 1.875"
Upper Drive	12 Tooth Involute Spline .600 P.D. or Tongue .55" x 10"
Upper Drive Speed Ratio to Crankshaft	1.5:1
Upper Drive Rotation (Facing Drive)	Counterclockwise
Lower Drive Mount	Four .313" - 24 U.S.F. Studs .88 High - Equally Spaced on 5" Dia. Circle
Lower Drive	6 Square Splines .878" O.D.-, 698" I.D.
Lower Drive Speed Ratio to Crankshaft	1.5:1
Lower Drive Rotation (Facing Drive)	Counterclockwise

NOTE: With addition of adapter and coupling, the lower drive will assume all features of tongued upper drive.

Fuel Pump Mount	Four Run Fit, .313" - 24 U.S.F. Studs .88" High Spaced 2" x 2"
Fuel Pump Drive	11 Tooth Involute Spline - .4583" Pitch Dia.
Fuel Pump Speed Ratio to Crankshaft	1:1
Fuel Pump Rotation (Facing Drive)	Counterclockwise
Generator Mount	Six .375" - 24 U.S.F. Studs .94" High Equally Spaced on 5" Dia. circle
Generator Drive	16 Tooth Involute Spline-.800" Pitch Dia.
Generator Drive Speed Ratio to Crankshaft	1.5:1
Generator Drive Rotation (Facing Drive)	Clockwise
Gun Synchronizer Drive Speed Ratio To Crankshaft	9:16
Gun Synchronizer Rotation:	
L. H. (Facing Drive)	Counterclockwise
R. H. (Facing Drive)	Clockwise
Propeller Governor Mount	Four .313" - 24 U.S.F. Studs .94" High Spaced 2.125" x 2.125"
Propeller Governor Drive	12 Involute Splines - .600 Pitch Dia.
Propeller Governor Drive Speed Ratio to Crankshaft	1:1
Propeller Governor Drive Rotation (Facing Drive)	Clockwise
Starter Mount	Six .375" - 24 U.S.F. Studs .94" High Equally Spaced on 5" Dia. Circle
Starter Drive	3 Jaw Detachable Dog
Starter Speed Ratio to Crankshaft	1:1
Starter Rotation (Facing Rear of Engine)	Clockwise
Tachometers:	
L. H. (Electric) Mount	Four .250" - 28 U.S.F. Studs .68" High Spaced 1.875" x 1.875"
Drive	.250" Square Hole
R. H. (Mechanical) Thread	.875" - 18 U.S.F.
Tachometer Shafts Rotation (Facing Drive)	Clockwise
Tachometer Shafts Speed Ratio to Crankshaft	.5:1

INSTRUMENT CONNECTIONS

Air Scoop Pressure Connection Carburetor Flange Thread	.125" Std. Pipe Tap
Fuel Pressure Regulator Vent Connection	.125" Std. Pipe Tap
Manifold Pressure Connection (Upper Left Hand Side of Rear Cover)	
Thread	.125" Std. Pipe Tap
Fitting	No. 50 Drill
Oil Pressure Connections:	
Engine, Accessory Drive and Starter Shaft	.125" Std. Pipe Tap
Engine, Propeller End	.125" Std. Pipe Tap
Torque Indicator (Engines Supplied with Torquemeter)	.125" Std. Pipe Tap
Oil Inlet and Outlet Thermometer Connections - Thread	.625" - 18 U.S.F.
Thermocouple, Spark Plug Type-Thread	No. 12 - 28 U.S.F.

ACCESSORIES AND WEIGHTS

Standard Equipment	Weight
Carburetor, Bendix Stromberg Injection PD-12-H-2 (Complete)	45.00#
Magnetos, Scintilla SF9L-4 (Shielded)	33.00#
Ignition Wiring (Shielded)	20.00#
Spark Plugs, Type Aero LS38C	5.00#

Priming System	2.00#
Exhaust Flanges and Gaskets, Per Set	4.00#
Cylinder Air Deflectors (As Delivered on Engine)	20.00#
Accessory Drive Covers	2.00#
Total Dry Weight	1308.00#
Tool Kit	18.00#

Model R-1820-71

Model	R-1820-71
Type	Single Row, Static Radial, Air Cooled
Number of Cylinders	9
Bore	6.125"
Stroke	6.875"
Piston Displacement	1823 Cu. In.
Compression Ratio	6.70:1
Blower Gear Ratio	7.00:1
Blower Diameter	11.0"
Rated Speed, in RPM	2300
Rated BHP/RPM at Sea Level	1000/2300
Rated BHP/RPM at Altitude (6900 Ft.)	1000/2300
Take-Off BHP/RPM	1200/2500
Rotation of Crankshaft (From Anti-propeller End)	Clockwise
Rotation of Propeller (From Anti-propeller End)	Clockwise
Propeller Reduction Gear Ratio	.666 (3:2)
Propeller Shaft Spline Size	S.A.E. #50
Average Weight of Engine	1308#
Overall Length of Engine	50.04"
Position of Center of Gravity:	
Distance aft of Thrust Nut Front Face	14.90"
Distance forward of Rear Face of Mounting Bosses	7.50"
Distance above Centerline of Crankshaft	0.375"
Diameter of Mounting Bolt Circle	23.37"
Number of Mounting Bolts	9
Overall Diameter of Engine	55.10"

IGNITION

Magneto Type	Scintilla SF9L4
Rotation of Magneto Drive (From Anti-propeller End)	Clockwise
Magneto Drive Shaft Speed Ratio to Crankshaft	1.125
Spark Plug Gap	.012"
Spark Plug Type	BG-298-GS
Spark Timing on No. 1 Cylinder:	
Left Magneto (Rear Plugs) - Degree B.T.C.	20°
Right Magneto (Front Plugs) - Degree B.T.C.	20°

VALVES AND TIMING

Intake Opens - Degree B.T.C.	15°
Intake Closes - Degree A.B.C.	44°
Exhaust Opens - Degree B.B.C.	74°
Exhaust Closes - Degree A.T.C.	25°
Intake Remains Open, Crankshaft Degrees	239°
Exhaust Remains Open, Crankshaft Degrees	279°
Valve Lift	.562"
Valve Rocker Clearance-Cold	.010"
Timing Clearance	.075"

Deleted by revision dated 12-10-42.

FUEL SYSTEM

Carburetor Type	Bendix Stromberg Injection PD12H3
Fuel:	
Specification	AN-VV-F-781
Octane	100
Fuel Inlet Connection - Thread	.750 Std. Pipe Tap
Supercharger Drain Valve Connection - Thread	.250 Std. Pipe Tap
Priming System Inlet Connection - Thread	.125 Std. Pipe Tap

LUBRICATION SYSTEM

Deleted by revision 12-10-42.

Grade of Oil Desired in Flight - Specification	AN-VV-O-446
Oil Pump Drive Shaft Speed Ratio to Crankshaft	1.125:1
Rotation of Oil Pump Drive Shaft (Facing Drive)	Counterclockwise
Oil Pump Inlet Flange Connection - Thread	1"
Oil Pump Outlet Flange Connection - Thread	1"
Oil Tank Vent Connection - Thread	.375"

ACCESSORY DRIVES

Dual Accessory Drive:	
Upper Mount	Four .250" - 28 U.S.F. Studs .78" High Spaced 1.875" x 1.875"
Upper Drive	12 Tooth Involute Spline .600 P.D.
Upper Drive Speed Ratio to Crankshaft	1.5:1
Upper Drive Rotation (Facing Drive)	Counterclockwise
Lower Drive Mount	Four .313" - 24 U.S.F. Studs .82" High - Equally Spaced on 5" Dia. Circle
Lower Drive	12 Tooth Involute Spline .600 P.D.
Lower Drive Speed Ratio to Crankshaft	1.5:1
Lower Drive Rotation (Facing Drive)	Counterclockwise
Fuel Pump Mount	Four Run Fit .313" - 24 U.S.F. Studs .38" High Spaced 2" x 2"
Fuel Pump Drive	11 Tooth Involute Spline - .4583" Pitch Dia.
Fuel Pump Speed Ratio to Crankshaft	1:1
Fuel Pump Rotation (Facing Drive)	Counterclockwise
Generator Mount	Six .375" - 24 U.S.F. Studs .94" High Equally Spaced on 5" Dia. Circle
Generator Drive	16 Tooth Involute Spline - .800" Pitch Dia.
Generator Drive Speed Ratio to Crankshaft	1.5:1
Generator Drive Rotation (Facing Drive)	Clockwise
Gun Synchronizer Drive Speed Ratio to Crankshaft	2:3
Gun Synchronizer Rotation:	
L. H. (Facing Drive)	Counterclockwise
R. H. (Facing Drive)	Clockwise
Propeller Governor Mount	Four .313" - 24 U.S.F. Studs .94" High Spaced 2.125" x 2.125"
Propeller Governor Drive	12 Involute Splines - .600 Pitch Dia.
Propeller Governor Drive Speed Ratio to Crankshaft	1:1
Propeller Governor Drive Rotation (Facing Drive)	Clockwise
Starter Mount	Six .375" - 24 U.S.F. Studs .94" High Equally Spaced on 5" Dia. Circle
Starter Drive	3 Jaw Detachable Dog
Starter Speed Ratio to Crankshaft	1:1
Starter Rotation (Facing Rear of Engine)	Clockwise
Tachometers:	
L. H. (Electric) Mount	Four .250" - 28 U.S.F. Studs .68" High Spaced 1.875" x 1.875"
Drive	.250" Square Hole
R. H. (Mechanical) Thread	.875" - 18 U.S.F.
Tachometer Shafts Rotation (Facing Drives)	Clockwise
Tachometer Shafts Speed Ratio to Crankshaft	.5:1

INSTRUMENT CONNECTIONS

Air Scoop Pressure Connection Carburetor Flange Thread	.125" Std. Pipe Tap
Fuel Pressure Regulator Vent Connection	.125" Std. Pipe Tap
Manifold Pressure Connection (Upper Left Hand Side of Rear Cover)	
Thread	.125" Std. Pipe Tap
Fitting	No. 50 Drill
Oil Pressure Connections:	
Engine, Accessory Drive and Starter Shaft	.125" Std. Pipe Tap
Engine, Propeller End	.125" Std. Pipe Tap
Oil Inlet and Outlet Thermometer Connection - Thread	.625" - 18 U.S.F.
Thermocouple, Spark Plug Type - Thread	No. 12 - 28 U.S.F.

ACCESSORIES AND WEIGHTS

Standard Equipment	Weight
Carburetor, Bendix Stromberg Injection PD-12-H-3 (Complete)	45.00#
Magnetos, Scintilla SF9L-4 (Shielded)	33.00#
Ignition Wiring (Shielded)	20.00#

Model R-1820-71

Spark Plugs, Type BG-298-GS	5.00#
Priming System	2.00#
Exhaust Flanges and Gaskets, Per Set	4.00#
Cylinder Air Deflectors (As Delivered on Engine)	20.00#
Accessory Drive Covers	2.00#
Total Dry Weight	1308.00#
Tool Kit	18.00#

Model R-1820-73

Model	R-1820-73
Type	Single Row, Static Radial, Air Cooled
Number of Cylinders	9
Bore	6.125"
Stroke	6.875"
Piston Displacement	1823 Cu. In.
Compression Ratio	6.70:1
Blower Gear Ratio	7.00:1
Blower Diameter	11.0"
Rated Speed, in RPM	2300
Rated BHP/RPM at Sea Level	1000/2300
Rated BHP/RPM at Altitude (25,000 Ft.)	1000/2300
Take-Off BHP/RPM	1200/2500
Rotation of Crankshaft (From Anti-propeller End)	Clockwise
Rotation of Propeller (From Anti-propeller End)	Clockwise
Propeller Reduction Gear Ratio	.666 (3:2)
Propeller Shaft Spline Size	S.A.E. No. 50
Average Weight of Engine	1308#
Overall Length of Engine	48.22"
Position of Center of Gravity:	
Distance aft of Thrust Nut Front Face	14.76"
Distance forward of Rear Face of Mounting Bosses	7.38"
Distance above Centerline of Crankshaft	0.26"
Diameter of Mounting Bolt Circle	23.37"
Number of Mounting Bolts	9
Overall Diameter of Engine	55 1/8"

IGNITION

Magneto Type	Scintilla SF9L4
Rotation of Magneto Drive (From Anti-propeller End)	Clockwise
Magneto Drive Shaft Speed Ratio to Crankshaft	1.125
Spark Plug Gap	.012"
Spark Plug Type	Champion C34S or Aero LS38C
Spark Timing on No. 1 Cylinder:	
Left Magneto (Rear Plugs) - Degrees B.T.C.	20°
Right Magneto (Front Plugs) - Degrees B.T.C.	20°

VALVES AND TIMING

Intake Opens - Degrees B.T.C.	15°
Intake Closes - Degrees A.B.C.	44°
Exhaust Opens - Degrees B.B.C.	74°
Exhaust Closes - Degrees A.T.C.	25°
Intake Remains Open, Crankshaft Degrees	239°
Exhaust Remains Open, Crankshaft Degrees	279°
Valve Lift	.552"
Valve Rocker Clearance - Cold	.010"
Timing Clearance	.075"

Deleted by revision 12-10-42.

FUEL SYSTEM

Carburetor Type	Bendix Stromberg Injection PD12H2
Fuel:	
Specification	AN-VV-F-781
Octane	100
Fuel Inlet Connection - Thread	.750 Std. Pipe Tap
Supercharger Drain Valve Connection - Thread	.250 Std. Pipe Tap
Priming System Inlet Connection - Thread	.125 Std. Pipe Tap

LUBRICATION SYSTEM

Deleted by revision dated 12-10-42.

Grade of Oil Desired in Flight - Specification	AN-VV-O-446
Oil Pump Drive Shaft Speed Ratio to Crankshaft	1.125:1
Rotation of Oil Pump Drive Shaft (Facing Drive)	Counterclockwise
Oil Pump Inlet Flange Connection - Thread	1"
Oil Pump Outlet Flange Connection - Thread	.750"
Oil Tank Vent Connection - Thread	.750"

ACCESSORY DRIVES

Dual Accessory Drive:	
Upper Mount	Four .250" - 28 U.S.F. Studs .78" High Spaced 1.875" x 1.875"
Upper Drive	12 Tooth Involute Spline .600 P.D. or Tongue .55" x .10"
Upper Drive Speed Ratio to Crankshaft	1.5:1
Upper Drive Rotation (Facing Drive)	Counterclockwise
Lower Drive Mount	Four .313" - 24 U.S.F. Studs .88" High - Equally Spaced on 5" Dia. Circle
Lower Drive	6 Square Splines .878" O.D. - .698" I.D.
Lower Drive Speed Ratio to Crankshaft	1.5:1
Lower Drive Rotation (Facing Drive)	Counterclockwise

NOTE: With addition of adapter and coupling, the lower drive will assume all features of tongued upper drive.

Fuel Pump Mount	Four Run Fit .313" - 24 U.S.F. Studs .88" High Spaced 2" x 2"
Fuel Pump Drive	11 Tooth Involute Spline - .4583" Pitch Dia.
Fuel Pump Speed Ratio to Crankshaft	1:1
Fuel Pump Rotation (Facing Drive)	Counterclockwise
Generator Mount	Six .375" - 24 U.S.F Studs .94" High Equally Spaced on 5" Dia. Circle
Generator Drive	16 Tooth Involute Spline - .800" Pitch Dia.
Generator Speed Ratio to Crankshaft	1.5:1
Generator Drive Rotation (Facing Drive)	Clockwise
Gun Synchronizer Drive Speed Ratio to Crankshaft	2:3
Gun Synchronizer Rotation:	
L. H. (Facing Drive)	Counterclockwise
R. H. (Facing Drive)	Clockwise
Propeller Governor Mount	Four .313" - 24 U.S.F. Studs .94" High Spaced 2.125" x 2.125"
Propeller Governor Drive	12 Involute Splines - .600" Pitch Dia.
Propeller Governor Drive Speed Ratio to Crankshaft	1:1
Propeller Governor Drive Rotation (Facing Drive)	Clockwise
Starter Mount	Six .375" - 24 U.S.F. Studs .94" High Equally Spaced on 5" Dia. Circle
Starter Drive	3 Jaw Detachable Dog
Starter Speed Ratio to Crankshaft	1:1
Starter Rotation (Facing Rear of Engine)	Clockwise
Tachometers:	
L. H. (Electric) Mount	Four .250" - 28 U.S.F. Studs .68" High Spaced 1.875" x 1.875"
Drive	.250" Square Hole
R. H. (Mechanical) Thread	.875" - 18 U.S.F.
Tachometer Shafts Rotation (Facing Drive)	Clockwise
Tachometer Shafts Speed Ratio to Crankshaft	.5:1

INSTRUMENT CONNECTIONS

Air Scoop Pressure Connection Carburetor Flange Thread	.125" Std. Pipe Tap
Fuel Pressure Regulator Vent Connection	.125" Std. Pipe Tap
Manifold Pressure Connection (Upper Left Hand Side of Rear Cover)	
Thread	.125" Std. Pipe Tap
Fitting	No. 50 Drill
Oil Pressure Connections:	
Engine, Accessory Drive and Starter Shaft	.125" Std. Pipe Tap
Engine, Propeller End	.125" Std. Pipe Tap
Torque Indicator (Engines Supplied with Torquemeter)	.125" Std. Pipe Tap
Oil Inlet and Outlet Thermometer Connection - Thread	.625" - 18 U.S.F.
Thermocouple, Spark Plug Type - Thread	No. 12 - 28 U.S.F.

Model R-1820-73

ACCESSORIES AND WEIGHTS

Standard Equipment	Weight
Carburetor, Bendix Stromberg Injection PD-12-H-2 (Complete)	45.00#
Magnetos, Scintilla SF9L-4 (Shielded)	33.00#
Ignition,Wiring (Shielded)	20.00#
Spark Plugs, Type Aero LS38C	5.00#
Priming System	2.00#
Exhaust Flanges and Gaskets, Per Set	4.00#
Cylinder Air Deflectors (As Delivered on Engine)	20.00#
Accessory Drive Covers	2.00#
Total Dry Weight	1308.00#
Tool Kit	18.00#

Model R-1820-87

Model	R-1820-87
Type	Single Row, Static Radial, Air Cooled
Number of Cylinders	9
Bore	6.125"
Stroke	6.875"
Piston Displacement	1823 Cu. In.
Compression Ratio	6.70:1
Blower Gear Ratio	7.134 and 10.04:1
Blower Diameter	11.0"
Rated Speed, in RPM	2300
Rated BHP/RPM at Sea Level	1000/2300
Rated BHP/RPM at 6900 Ft. (7.134:1 Blower)	1000/2300
Rated BHP/RPM at 15,200 Ft. (10.04:1 Blower)	900/2300
Take-Off BHP/RPM at Sea Level	1200/2500
Military Rated BHP/RPM at 4200 Ft. (7.134:1 Blower)	1200/2500
Military Rated BHP/RPM at 14,200 Ft. (10.04:1 Blower)	1000/2500
Rotation of Crankshaft (From Anti-propeller End)	Clockwise
Rotation of Propeller (From Anti-propeller End)	Clockwise
Propeller Reduction Gear Ratio	.666 (3:2)
Propeller Shaft Spline Size	S.A.E. No. 50
Average Weight of Engine	1315#
Overall Length of Engine	48.22"
Position of Center of Gravity:	
Distance aft of Thrust Nut Front Face	14.90"
Distance Forward of Rear Face of Mounting Bosses	7.50"
Distance above Centerline of Crankshaft	0.375"
Diameter of Mounting Bolt Circle	23.37"
Number of Mounting Bolts	9
Overall Diameter of Engine	55.10"

IGNITION

Magneto Type	Scintilla SF9L4
Rotation of Magneto Drive (From Anti-Propeller End)	Clockwise
Magneto Drive Shaft Speed Ratio to Crankshaft	1.125
Spark Plug Gap	.012"
Spark Plug Type	Champion C34S
Spark Timing on No. 1 Cylinder:	
Left Magneto (Rear Plugs) - Degrees B.T.C.	20°
Right Magneto (Front Plugs) - Degrees B.T.C.	20°

VALVES AND TIMING

Intake Opens - Degrees B.T.C.	15°
Intake Closes - Degrees A.B.C.	44°
Exhaust Opens - Degrees B.B.C.	74°
Exhaust Closes - Degrees A.T.C.	25°
Intake Remains Open, Crankshaft Degrees	239°
Exhaust Remains Open, Crankshaft Degrees	279°
Valve Lift	.562"
Valve Rocker Clearance - Cold	.010"
Timing Clearance	.075"

Deleted by revision dated 12-10-42.

Model R-1820-87

FUEL SYSTEM

Carburetor Type	Bendix Stromberg Injection PD12H3
Fuel:	
Specification	AN-VV-F-781
Octane	100
Fuel Inlet Connection - Thread	.750 Std. Pipe Tap
Supercharger Drain Valve Connection - Thread	.250 Std. Pipe Tap
Primer Connection	Nut and Cone Furnished with Nipple 250 O.D. Tubing

LUBRICATION SYSTEM

Deleted by revision dated 12-10-42.

Grade of Oil Desired in Flight - Specification AN-VV-O-446	Grade 1120
Oil Pump Drive Shaft Speed Ratio to Crankshaft	1.125:1
Rotation of Oil Pump Drive Shaft (Facing Drive)	Counterclockwise
Oil Pump Inlet Flange Connection - Thread	1"
Oil Pump Outlet Flange Connection - Thread	1"
Oil Vent Connection - Thread	.750"

ACCESSORY DRIVES

Dual Accessory Drive:	
Upper Mount	Four .250" - U.S.F. Studs .78" High Spaced 1.875" x 1.875"
Upper Drive	12 Tooth Involute Spline .600 P.D.
Upper Drive Speed Ratio to Crankshaft	1.5:1
Upper Drive Rotation (Facing Drive)	Counterclockwise
Lower Mount	Four .313" - 24 U.S.F. Studs .82" High - Equally Spaced on 5" Dia. Circle
Lower Drive	12 Tooth Involute Spline .600 P.D.
Lower Drive Speed Ratio to Crankshaft	1.5:1
Lower Drive Rotation (Facing Drive)	Counterclockwise
Fuel Pump Mount	Four Run Fit .313" - U.S.F. Studs .88" High Spaced 2" x 2"
Fuel Pump Drive	11 Tooth Involute Spline - .4583" Pitch Dia.
Fuel Pump Speed Ratio to Crankshaft	1:1
Fuel Pump Rotation (Facing Drive)	Counterclockwise
Generator Mount	Six .375" - 24 U.S.F. Studs .94" High Equally Spaced on 5" Dia. Circle
Generator Drive	16 Tooth Involute Spline - .800" Pitch Dia.
Generator Drive Speed Ratio to Crankshaft	1.5:1
Generator Drive Rotation (Facing Drive)	Clockwise
Gun Synchronizer Drive	Not Installed
Propeller Governor Mount	Four .313" - 24 U.S.F. Studs .88" High Spaced 2.125" x 2.125"
Propeller Governor Drive	12 Involute Splines - .600" Pitch Dia.
Propeller Governor Drive Speed Ratio to Crankshaft	1:1
Propeller Governor Drive Rotation (Facing Drive)	Clockwise
Starter Mount	Six .375" - 24 U.S.F. Studs .94" High Equally Spaced on 5" Dia. Circle
Starter Drive	3 Jaw Detachable Dog
Starter Speed Ratio to Crankshaft	1:1
Starter Rotation (Facing Rear of Engine)	Clockwise
Tachometers:	
L. H. (Electric) Mount	Four .250" - 28 U.S.F. Studs .68" High, Spaced 1.875" x 1.875"
Drive	.250" Square Hole
R. H. (Mechanical) Thread	.875" - 18 U.S.F.
Tachometer Shafts Rotation (Facing Drives)	Clockwise
Tachometer Shafts Speed Ratio to Crankshaft	.5:1

INSTRUMENT CONNECTIONS

Air Scoop, Pressure Connection Carburetor Flange Thread	.125" Std. Pipe Tap
Fuel Pressure Regulator Vent Connection	.125" Std. Pipe Tap
Manifold Pressure Connection (Upper Right Hand Side of Rear Cover)	
Thread	.125" Std. Pipe Tap
Fitting	No. 50 Drill
Oil Press Connections:	
Engine, Accessory Drive and Starter Shaft	.125" Std. Pipe Tap
Engine, Propeller End	.125" Std. Pipe Tap
Torque Indicator (Engines Supplied with Torquemeter)	.125" Std. Pipe Tap
Oil Inlet and Outlet Thermometer Connection Thread	.625" - 18 U.S.F.

Model R-1820-87

ACCESSORIES AND WEIGHTS

Standard Equipment	Weight
Carburetor, Bendix Stromberg Injection PD-12-H-3 (Complete)	45.00#
Magnetos, Scintilla SF9L-4 (Shielded)	33.00#
Ignition Wiring (Shielded) Titeflex	20.00#
Spark Plugs, Type Champion C34S	5.00#
Exhaust Flanges and Gaskets, Per Set	4.00#
Cylinder Air Deflectors (As Delivered on Engine)	20.00#
Accesory Drive Covers	2.00#
Total Dry Weight	1315.00#
Tool Kit	18.00#

SECTION III

GENERAL DESCRIPTION

1. Difference Between Models

a. The Model R-1820-65, R-1820-71, R-1820-73, R-1820-87, and R-1820-97 engines are basically the same in design and construction. However, there are several differences between these models which affect the installation, operation, servicing, and overhaul of the engines.

b. These differences are as follows:

	R-1820-65 and -97	R-1820-71	R-1820-73	R-1820-87
Reduction Gear Ratio	16:9	3:2	3:2	3:2
Gun Synchronizer to Crankshaft Speed Ratio	9:16	2:3	None	None
Supercharger Drive Ratio	7.00:1	7.00:1	7.00:1	7.134:1 10.04:1
Turbo Supercharger	Yes	No	Yes	No
Bendix Stromberg Injection Carburetor	PD12H2	PD12H3	PD12H2	PD12H3
External Governor Oil Line	All -97, some -65	No	No	No
Type of Breather	Crankcase	Crankcase	Crankcase	Crankshaft
External Oil Scavenge Line	R-1820-97 only	No	No	No
Oil Pump Check Valve	Yes	Yes	Yes	No
Spark Plugs	Aero LS38C or Champion C34S	BG 298GS	Aero LS38C or Champion C34S	Champion C34s or A.C. LS85
Cylinder Hold-down Capscrews-Head Size	9/16"	9/16"	9/16"	1/2"

c. Engines equipped with turbo superchargers require a special supercharger drain valve assembly.

d. R-1820-87 engines are equipped with heavy wire spring hose clamps at the push rod housing hose connections, as compared to the wide band type clamp used on the other models. The new spring clamps are installed and removed by absorbing the spring pressure with special pliers.

e. For further information concerning these differences, refer to paragraph 2. of this section.

f. Differences in oil pump connections may be obtained by referring to the Tables of Specifications.

g. The R-1820-97 engines and some R-1820-65 engines incorporate an external propeller governor oil supply line, leading from the left hand gun synchronizer impulse generator location on the supercharger rear housing to the low pressure governor oil supply passage in the crankcase front section. The R-1820-97 also incorporates an external oil scavenge line, leading from the oil sump strainer to the oil pump. Installation of this external oil scavenge line in former R-1820-65 engines changed this model to the R-1820-97, and the engine data plate was re-stamped accordingly.

2. General Discussion of Construction and Purpose

a. Cylinders. - (1) The cylinders are built up by shrinking threaded cast aluminum alloy heads on forged steel barrels. Form-fit, ground buttress type cylinder head attaching threads are used. The exhaust port boss faces toward the rear of the engine and is provided with four studs for attachment of the exhaust stacks. The intake port boss is located at the rear of the cylinder head and faces to the

right and downward. Rubber packing is used between the intake pipe flange and the cylinder head to form a tight seal.

(2) The valves are inclined to the centerline of the cylinder at an angle permitting a hemispherical combustion chamber. Bronze valve guides and steel valve seats are shrunk into the cylinder head.

(3) Two bronze spark plug bushings are screwed and pinned in the front and rear of the cylinder head. The bushings, located just above the main horizontal cooling fins of the cylinder head, are symmetrical and at 90° to each other. Each bushing is surrounded by deep vertical cooling fins.

(4) The intake and exhaust rocker boxes of each cylinder are provided with four studs for securing the rocker box covers. Bosses are cast integral with the cylinder at the front and rear of each rocker box and are equipped with studs for attachment of the engine cowling. Push rod housing connecting sleeves are screwed into the forward end of the rocker boxes forming oil-tight seals.

(5) The cylinder barrel, with integral cooling fins, bolting flange, and threads to secure the cylinder head, is machined from a steel forging. The surface of the cylinder bore is nitrided to increase the life of the cylinder. Pressure type cylinder barrel and cylinder head air deflectors and air cooled type spark plugs are used. Twenty holes are provided in the bolting flange for attaching the cylinder assembly to the crankcase. Capscrews and spherical seat washers are used to bolt the cylinders to the steel crankcase.

(6) A boss, located just forward of the intake pipe flange on each cylinder intake port, is drilled and tapped to receive either a priming line fitting or a plug.

b. Valve Operating Mechanism. - The operation of the valves is accomplished through a cam which is located in the crankcase front section. The cam consists of a hardened steel ring with two sets of lobes on its periphery.

c. Valves and Valve Springs. - (1) The intake valves are of the tulip type and the exhaust valves are of the mushroom type. Both types of valves are machined from forgings of heat resisting steel. The valve face angles are 44° 15' to 44° 30' for both intake and exhaust.

(2) The exhaust valve is hollow and is partially filled with sodium to assist in conducting heat from the valve head. To insure long life, stellite is welded on the seat of the valve.

(3) The intake valve stems are smaller in diameter than the exhaust valves, and are of a solid cross section.

(4) The intake and exhaust valves are fitted with three concentric coil springs which are interchangeable with each other.

(5) The inner spring seats on a shoulder of the valve guide, while the intermediate and outer springs seat on the flat steel washers which rest on machined surfaces of the cylinder head. A shouldered steel washer is provided at the outer end of the springs and the assembly locked at the valve tip by a tapered, split lock ring.

d. Crankshaft and Propeller Shaft Construction. - (1) The crankshaft is of a two-piece construction, single throw type, machined from alloy-steel forgings.

(2) The front section of the crankshaft includes the drive shaft, front crankcheek, front dynamic damper counterweight, and the crankpin. The crankpin and drive shaft are bored for a lightness throughout except at the rear end of the crankpin where a web is left to prevent distortion when the rear crankcheek is clamped into position. A plug is pressed into the front end of the crankpin and is secured by a drilled capscrew which also serves as an oil metering jet. The hollow driveshaft is plugged at the crankcheek by a tight fitting plug which is secured in position by a tab lock and screw. In engines which breathe through the crankshaft, this plug is replaced by a breather tube support. The front crankcheek is of rectangular section drilled and slotted to accommodate the front dynamic damper and stops.

(3) The rear section of the crankshaft includes the crankshaft rear crankcheek, rear dynamic damper and crankshaft rear bearing journal. The upper end of the crank of the crankcheek is bored to receive the crankpin and is bored and threaded at the extreme upper end to receive the clamping screw. A slot is provided to permit a clamping action when the clamp screw is tightened.

(4) The general appearance of the dynamic damper is the same as that of the conventional counterweight. It is, in principle, a pendulum counterweight. Each unit consists of a counterweight supported on two floating pins which pass through the extended portion of the crankcheeks. The bushings in the rear dynamic damper assembly are of the floating type and lubricated by two oil passages drilled in the rear crankcheek. The component parts of the dynamic damper assemblies are locked to the crankshaft by stops bolted to the crank cheeks. The stops also limit the movement of the damper weights when the crankshaft is rotated by hand.

(5) The crankshaft is supported in the crankcase by a roller bearing directly forward of the front crankcheek and by a roller bearing directly behind the rear crankcheek. Both bearings are of the demountable type, the front incorporating sixteen rollers and the rear bearing eighteen rollers.

(6) The propeller shaft for the Model R-1820-65 engine is machined from a steel alloy forging and is hollow throughout its length. The shaft is supported by two steel-backed copper-lead bushings which ride on journals of the crankshaft front extension. A steel sleeve, shrunk in the propeller shaft between the two bushings, forms with the front bushing an annulus from which the hydro high pressure oil is taken for the operation of a hydromatic propeller. A flange forged integrally at the rear end of the shaft is drilled to accommodate the 24 pinion carrier ring attaching bolts. The flange is drilled with eight passages for pressure lubrication of the pinion bushings. The propeller shaft is threaded on its outside diameter near the mid-section for the thrust nut and at its front-end for a propeller hub nut. The shaft is also splined at its front-end to receive an S.A.E. No. 50 propeller hub.

(7) The propeller shaft for the Model R-1820-71, -73, and -87 engine is also machined from a steel alloy forging and differs from the propeller shaft used in the Model R-1820-65 only in the respect that the flange is in the form of a spider having six pinion arms. Each arm is drilled and fitted with bronze bushings which carry the reduction gear pinions. The arms are also drilled with oil passages for pressure lubrication of the bushings.

(8) Since the Model R-1820-65, -71 -73 and -97 engines breathe through cored passages in the supercharger front housing, the hollow propeller shaft is blanked off at its front end with a steel adapter which is drilled for oil passages to accommodate a hydraulic propeller. A cover plate may be inserted into the inside diameter of the propeller shaft to blank off the oil passages for use with a non-hydraulic propeller.

(9) The Model R-1820-87 engine breathes through the crankshaft, and for this purpose it incorporates a breather tube in its hollow driveshaft. The anti-propeller end of the breather tube has an oil-tight fit in a support at the front crankcheek, while the flange at its propeller end seats on the propeller shaft front bushing. The annulus thus formed between the breather tube and the driveshaft acts as a reservoir for engine oil. The flange is drilled for two sets of holes to allow for the unrestricted flow of both hydro low and hydro high pressure oil to the propeller. A gasket, an adapter, and a retaining nut complete an oil-tight passage for the hydro oil to the propeller. A plug is used on the adapter to blank off the oil passages when a non-hydraulic propeller is used.

e. Reduction Gear Assembly. - (1) R-1820-65 and -97 - .5625 (16:9) Reduction Gear Ratio:

(a) The reduction gear for the Model R-1820-65 and -97 engines consists essentially of a large internal driving gear splined and shrunk to the crankshaft; a propeller shaft assembly having twenty planetary type pinion gears mounted on a carrier ring which is bolted to the propeller shaft flange; a stationary reduction gear support which is bolted to the crankcase front section; and a stationary reduction gear meshing with the stationary reduction gear support and pinion assembly.

(b) The reduction gear drive is as follows: The reduction driving gear meshes with the planetary pinion gears causing them to travel around the rim of the stationary reduction gear carrying the propeller shaft to which they are attached in the same direction of rotation as the crankshaft but at 9/16 of its speed.

(c) The reduction driving gear is machined from a nitralloy steel forging with internal spur gear teeth cut inside the rim to drive the pinion gears. Splines are cut on the inside diameter of the hub for crankshaft attachment and teeth cut on the hub outside diameter form the cam drive gear. The outside rim is provided with a timing scale ranging from 0° to 35° for magneto and valve timing checks. Three tapped puller holes are located near the hub for diaassembly purposes.

(d) The pinion carrier ring is machined from a steel forging with twenty integral, hollow trunnions upon which the pinion gears and bushings are supported. Each trunnion is drilled with two holes interconnecting an oil groove on its outside diameter.

(e) The twenty pinion gears are machined from steel forgings and are case hardened on the inside diameter and tooth surfaces. The bronze pinion gear bushings are plated all over with a thin coat of lead. The bushings are a loose fit in the pinions and on the trunnions. Each bushing is shouldered on its front end, drilled with six oil holes at its mid-section and spotfaced for identification marks on the front face of the shoulder. Twenty flanged head bolts and mating nuts are utilized for attachment of the pinions. The shank of each bolt is necked to allow for oil circulation.

(f) The stationary reduction gear is machined from an alloy steel forging and is tapped with twelve holes to accommodate the ten 3/8" and two 5/16" crankcase front section retaining bolts. The gear is mounted with a loose fit on the pilot of a support machined from an aluminum alloy casting. This support has an alloy steel sleeve shrunk in its inside diameter on which the hydro oil seal assembly rides. The sleeve and support are drilled for oil passages to and from the governor pump as described in paragraph 2 o, of this section. A steel guard ring is supported between the stationary reduction gear and the support to eliminate damage to the reduction gear system in the event of a pinion accidentally becoming unattached.

(g) The hydro oil seal spacer assembly consists of a carbon steel sleeve which supports six cast iron rings in grooves cut in its outside diameter. The oil seal rings are arranged in groups of two on each side of the two drilled sections of the sleeve, where oil is transferred to and from the governor pump as described in paragraph 2.o. of this section.

(h) Propeller shaft thrust is absorbed by a ball bearing having a wide split or solid inner race which eliminates the use of a slinger ring customarily employed with this type of bearing. The front end of the inner race is grooved around its outside diameter to accommodate a puller for disassembly purposes. The eleven balls are retained by two plates riveted together.

(i) The stationary reduction gear support attaching capscrews also retain the crankcase front section flange and spacer. The flange is machined from a carburized chrome nickel forging and is cadmium plated on all surfaces except the bore, in which the thrust nut oil seal rings revolve. The spacer is finish machined from an aluminum forging.

(j) The thrust nut, which limits the end movement of the propeller shaft in the thrust bearing inner race, is machined from carburized chrome nickel steel and has three oil seal ring grooves on the rear outside diameter. The front end is shouldered with eight slots cut into the rim for use of a spanner wrench. The three cast iron rings provide an effective seal against oil leakage, and prevent the thrust nut from rubbing directly on the flange.

(2) R-1820-71, -73 and -87 - .666 (3:2) Reduction Gear Ratio: (a) The reduction gear for the Model R-1820-71, -73 and -87 engines consists essentially of a large internal driving gear splined and shrunk to the crankshaft; a propeller shaft assembly incorporating six planetary type pinion gears mounted on arms which are integral with the propeller shaft flange, and a stationary reduction gear which is bolted to the crankcase front section.

(b) The reduction gear drive is as follows: The reduction driving gear meshes with the planetary pinion ears causing them to travel around the rim of the stationary reduction gear carrying the propeller shaft to which they are attached in the same direction of rotation as the crankshaft but at 2/3 of its speed.

(c) The reduction driving gear is identical with the gear used in the .5625 reduction gear ratio system. Refer to paragraph 2.e.(1)(c) of this section.

(d) The six pinion gears are machined from steel alloy forgings and are case hardened on the inside diameter and tooth surfaces. Bronze nuts which screw into the pinions retain the pinions on the spider arms. Note that these nuts have left handed threads. The hubs of the pinion gears of the retaining nuts are drilled for lubrication of the pinion gear bushings.

(e) The stationary reduction gear is machined from an alloy steel forging and is drilled and tapped to accommodate the crankcase front section retaining bolts. The gear is drilled with oil passages which index with similar passages in the crankcase front section to supply oil to and from the propeller governor pump, as described in paragraph 2 o. of this section. A steel guard ring is mounted at the rear of the gear to eliminate damage to the reduction gear system in the event of a pinion accidentally becoming unattached.

(f) The hydro oil seal spacer assembly is similar to the spacer used in the .5625 reduction gear system. Refer to paragraph 2.e.(1)(h), above, for details.

(g) The propeller shaft thrust bearing is essentially the same as that used in the .5625 reduction gear assembly. Refer to paragraph 2.e.(1) (h), above, for details.

(h) The stationary reduction gear attaching bolts also retain the pinion guard ring, crankcase front section flange and spacer. The spacer and flange are similar in every respect to those used in the .5625 reduction gear system. Refer to paragraph 2.e.(1)(i), above, for details.

(i) For a complete description of the thrust nut refer to paragraph 2.e. (1)(j), above, for details.

f. Crankcase and Sump Construction. - (1) The crankcase is built up of six principal sections located from front to rear as follows: Crankcase front section, front main section, rear main section, supercharger front housing, supercharger rear housing, and supercharger rear cover.

(2) The crankcase front section is machined from a magnesium alloy casting. It supports the thrust bearing in a steel retainer which is shrunk into the forward portion of the section. A governor driveshaft in a bronze bushing is supported on the top centerline of the section. The reduction gear assembly is also housed in this portion of the crankcase as previously described in paragraph 2.e. of this section. The crankcase front section is attached to the front main case by capscrews.

(3) The main section of the crankcase consists of two alloy steel forgings which are parted at the cylinder centerline and attached by short steel bolts through internal lugs cast integrally with the cases. The forward wall of the crankcase front section is provided with a hub extended at the center of the web or diaphragm, to receive the cam bearing ring and cam. The bronze cam bearing ring is shrunk in the outside diameter of the hub. The front and rear roller bearings are assembled in steel

bearing retainer rings which are shrunk into the bore of the web of the front and rear cases. A wide rubber oil seal ring is used between the front main case and the crankcase front section to form an oil tight joint. A narrow seal ring is used between the rear main case and the supercharger front housing.

(4) The supercharger front housing is finish machined from a magnesium alloy casting having nine mounting lugs for supporting the engine and nine tapped bosses for intake pipe connections. The diaphragm or web of the supercharger front housing forms the forward wall of the diffuser section and distribution chambers. The impeller shaft front oil sleeve support is mounted on the diaphragm and held in place by a steel retainer ring which is secured to the diaphragm by eight short screws. This diaphragm is cored around the rim of the front face to form a breather passage as explained in paragraph 2.n. of this section. As the mixed charge is distributed to the intake pipes from this section, bosses with tapped holes are provided for a priming line and manifold pressure connection. The supercharger front housing is attached to the crankcase rear main crankcase by means of eighteen capscrews. Five plugs are permanently installed in the supercharger front section for manufacturing purposes and a crankcase breather relief valve is screwed into the remaining hole. Cored holes in the bottom of the housing form drainage and suction passages to the oil sump.

(5) The magnesium alloy supercharger rear housing forms the induction passages to the impeller entrance and forms the housing for all the accessory drive gears. The vaned type diffuser plate is attached to the forward end of the induction passage where it shrouds the impeller. The supercharger rear housing, which is attached to the supercharger front housing by studs, forms the rear wall of the diffuser chamber. A removable automatic filter is attached to the left side of the supercharger rear housing and seats near the center of the supercharger rear housing cover. Two gun synchronizers and a fuel pump are also mounted on the sides of this section. The impeller shaft oil seal assembly is supported in a steel sleeve which is shrunk in at the center of the diaphragm which forms the rear wall of the induction passage. Vent passages in the supercharger rear housing line up with similar passages in the supercharger front housing to balance the rear section and crankcase breather passages. Cored drainage and suction passages communicate with similar passages in the supercharger front housing.

(6) The supercharger rear housing cover is machined from a magnesium alloy casting in the form of a heavily ribbed flat plate, and is secured to the supercharger rear housing by capscrews. The rear cover provides mounting pads for the two magnetos, generator, starter, oil pump, and dual spare drive housing. Bushings in bosses of the front face of the cover form support for the accessory drive gears and the rear journal of the accessory drive and starter shaft. The cover is provided with the necessary pressure oil passages to lubricate all the accessory drives. Provision is made for an oil tank vent connection at the upper center of the cover.

(7) The oil sump is a magnesium alloy casting of irregular shape as required to fit between No. 5 and No. 6 cylinders. The drainage capacity of the sump is approximately one gallon when the engine is stopped, however the sump is kept nearly dry in normal operation by the scavenge oil pump. The forward part of the sump is attached to the crankcase front section by studs. Attachment of the rear two legs of the sump to the supercharger is also obtained by studs. A screened plug is screwed into the lower forward end of the sump with the screen fitting into a pilot to keep any coarse, foreign material from entering the oil circulation. A drain plug which is equipped with a permanent magnet is screwed into the bottom of the sump to trap any magnetic material. The oil from the rear crankcase sections drains into the sump through holes in the left arm of the sump, while the holes in the right arm communicate with holes in the supercharger front housing for breathing purposes.

g. Connecting Rod Construction. - (1) A one-piece banjo type master rod equipped with eight articulated rods is installed on the crankpin. The master rod is located in No. 1 cylinder.

(2) The master rod is machined from steel forgings with H-section shanks, the flanges of which are continuations of the thicker flanges of the channel section around the big end of the rod. A steel-backed kelmit lined crankpin bearing is shrunk into the big end bore of the rod and is restrained from turning by splines cut in the face of the knuckle pin lockplate. Eight holes are drilled through the flanges to support the knuckle pins. The knuckle pin holes are lightly chrome-plated so that the knuckle pins may be installed and removed without any damaging effect to the surfaces.

(3) The bearing end seal assembly consists essentially of a steel knuckle pin lock plate, a spacer spring, and an end seal disc for both the front and rear ends of the master rod bearing. The knuckle pin lock plate is provided with splines which mate with splines on the master rod bearing and eight tabs which are drilled for the eight attaching screws. Each tab is also drilled with an oil passage to provide lubrication to the knuckle pin bushings. A recess is provided in the front face of the lockplate for the spacer spring and end seal disc. A collar on the disc fits in the recess and the spring is located inside of the collar. The front face of the disc is held snugly against the front crankcheek by the spring to form an oil seal. A steel spacer fits over the opposite end of the master rod, completing the end seal assembly.

(4) The articulated rods are machined in I Section from steel forgings. The knuckle-pin and piston-pin ends of the rod are bored to accommodate the pressed in split-type, bronze bushings. The inside diameters of the bushings are finished with a burnishing broach.

(5) The knuckle pins are made from alloy steel and have nitrided bearing surfaces to prevent scuffing. The nitrided bearing surfaces of the knuckle pins are also lapped and polished. One end of the knuckle pins is drilled and tapped to accommodate the locking screws. A step is cut into the tapped end of the knuckle pins to lock the pins and also line up the oil holes. An oil chamber is drilled in the center of the pins and sealed off with a pressed-in plug. Holes drilled through the walls of the pins permit adequate lubrication of the mating knuckle pin bushing.

h. Piston and Piston Pin Construction. - (1) The pistons are full trunk type, heat treated aluminum die forgings. A domed head is used to secure the desired compression ratio. Cooling is effected by fins machined in the inside diameter of the skirt at the thrust and anti-thrust sides. The piston employs six ring grooves, five of which are above the piston pin bore, and one below. The top three grooves taper in slightly towards the center to accommodate the wedge type rings; the fourth and fifth grooves are of rectangular shape to take conventional compression rings which act as oil control rings. Ten holes are drilled in the fourth groove, five in the thrust and five in the anti-thrust sides. Twelve holes are drilled in the fifth groove, six in the thrust and six in the anti-thrust sides. The holes are drilled to permit efficient control of the oil. The single groove below the piston pin bore is square cut to accommodate the same type of ring as used in the fourth and fifth grooves. However, this ring is inverted to give a pumping action to the oil and permit a film of oil to be spread over the cylinder bore and piston.

(2) The piston pins are machined from alloy steel and have a case hardened bearing surface. The pins are of tubular cross section, and have ground bevels at each end. The piston pins float in the connecting rod bushings and in the pistons. They are located and retained in the pistons by coiled spring type retainers which are sprung into grooves located at each end of the piston pin bore.

i. Accessory Drive Mechanism. - (1) The supercharger and all of the accessories are driven by a forged steel extension shaft from the rear end of the crankshaft, through an accessory drive gear which is attached to the shaft by means of a flexible spring drive. The accessory drive gear is machined and case hardened from an alloy steel forging. The starter and accessory drive shaft is splined at its front end to mesh with a coupling which is splined to the rear crankcheek. The shaft is supported at its rear end by a bronze bushing lined boss on the rear cover. The journal at the rear end of the shaft has involute splines cut into the inside diameter which mate with a detachable starter dog. Holes are drilled in the journal wall section for the main oil feed into the center-drilled shaft. Two journals on the starter shaft support the supercharger impeller shaft. The three jawed starter dog is made of alloy steel with splines on its front end which mate with splines at the accessory drive and starter shaft rear end. A hollow aluminum alloy spacer is installed between the starter dog and accessory drive and starter shaft at assembly and machined to a length assuring proper end clearance at the spherical oil seal ring which is supported on a pilot of the starter dog.

(2) All principal drives are effected through spur gearing and are located in the supercharger rear housing with journals rotating in bushings pressed in bosses on the supercharger rear cover. The generator drive gear meshes with the supercharger intermediate drive pinion gear at the bottom. The supercharger intermediate drive gear is driven by the accessory drive gear. Both the oil pump and spare drive gears are dual with the larger gear of each meshing with the accessory drive gear, and each of the smaller gears mating with a magneto drive gear. The gun synchronizer gears are spiral and mesh with gear teeth cut into the center of the magneto drive shafts. A spiral fuel pump gear meshes with a gear cut in the center of the spare drive shaft.

(3) The generator, oil pump, and fuel pump drive gears are machined from alloy steel forgings with integral gear and shaft. The magneto and spare drive assemblies have forged steel gears attached to forged steel shafts by capscrews through the gear walls into the flanged shaft ends.

(4) The accessory drive shaft, generator, and fuel pump drive shaft bushings are machined from cast bronze material. The accessory drive and starter shaft bushing is provided with three circumferential grooves and three slots to line up the oil holes in the accessory drive and starter shaft and the rear cover. The magneto, oil pump, and spare drive bushings are machined from aluminum alloy. Each gun synchronizer is mounted in two bronze bushings which are pressed into an aluminum alloy support. The supports are attached to the sides of the supercharger rear housing. On engines where gun synchronizers are not to be used, substituting covers replace the gun synchronizer impulse generator supports.

(5) Provision for optional accessory drives is made possible by the use of a spur gear box attached to the supercharger rear housing cover at the spare drive mounting pad. The gear box is composed of a magnesium alloy casting studded for attachment of aluminum alloy cover plate. The bushings which support the gears are divided between the cover plate and the body of the gear box. The main drive gear is machined integral with a shaft that extends through the upper left hand wall of the housing to mate with the spare drive on the supercharger rear cover. This main drive gear meshes with an intermediate gear near the center of the housing to make up the primary or first gear train of the unit. The secondary train of gears, identified by their smaller teeth, consists of a secondary driving gear bolted to and turning with the primary intermediate gear and meshing with two accessory driving gears. To change the speed ratio of the accessory drives to the crankshaft, it is only necessary to replace the two gears in the primary gear train. All the gears are machined from alloy steel forgings. The lower accessory drive is supported by oilite bushings and the upper drive is supported by an oilite bushing in the cover and a bronze bushing in the housing. All of the other drives in the unit are supported by bronze bushings. Both the housing and cover of the unit are drilled with oil passages as described in paragraph 2.o. of this section. Splined drives are utilized with provisions of conversion to the tongue type by the addition of steel couplings. An adapter equipped with drilled oil passages may be used on the lower drive if it is desired to mount a smaller accessory than the studs in the cover pad accommodate.

(6) Tachometer Drives. Provision is made at the rear end of the oil pump for two tachometer drives. The tachometer drives are effected by a small drive shaft which is splined at one end to mate with similar splines in the pressure pump drive shaft. Oil leakage is prevented by the use of spring loaded plunger, neophrene ring oil seals. One tachometer drive is the standard threaded type connection and the other a flange type mount. Both tachometer drives have the same speed ratio and rotate in the same direction.

(7) Section II and the Engine Installation Drawing contain specific information pertinent to all accessory drives.

j. Supercharger. - (1) General: The centrifugal type supercharger consists of an impeller or "blower", a diffuser chamber, a distribution chamber, and an impeller drive mechanism.

(2) Impeller: The impeller operates with the inlet side facing the rear of the engine, and is mounted on a splined, hollow shaft which is supported by journals on the crankshaft extension. The impeller shaft is machined from a steel forging with spur gear teeth on its rear end, and two steel backed bronze bushings pressed in its inside diameter at each end. The impeller thrust is absorbed by a self-aligning bronze thrust washer which makes a spherical seat on a steel retainer equipped with an oil seal ring and secured to the supercharger rear housing by flat head screws. A bronze thrust washer is provided in front of the impeller shaft gear and a laminated shim beneath the steel retainer attaching flange for end clearance adjustment. Steel oil seal sleeves each grooved to accommodate four bronze oil seal rings are slid on the impeller shaft at the front and rear ends of the impeller and the whole assembly retained by a nut and nut lock at the threaded front end of the shaft. As explained in this section, the front and rear impeller oil seals are supported by steel sleeves in the front and rear supercharger housings and the induction passage to the impeller is cast into the upper part of the supercharger front housing. A steel tube extends from the top of the supercharger rear housing, at the rear wall of the induction passage, to an annulus around the midpoint of the impeller rear oil seal assembly. This tube vents the impeller front and rear oil seal assemblies to the atmosphere by means of two splines omitted from the impeller shaft. Venting at this point prevents oil from leaking into the diffuser section by rendering ineffective any suction or pressure that might arise at either impeller oil seal.

(3) Diffuser Chamber: As described in this section, the aluminum alloy diffuser plate is attached to the supercharger rear housing by flat head screws. This plate shrouds the impeller and forms narrow passages through which the mixture is discharged into the distribution chamber or front supercharger housing. The front face of the diffuser is formed by the diaphragm of the front supercharger housing. Vanes cut on the diffuser plate form tangential passages.

(4) Distribution Passage: The distribution chamber is an annular passage in supercharger front housing around the diffuser chamber. The nine intake pipes are attached to the circumference of this section through tapped radial ports. The rear wall of the chamber is formed by the supercharger rear housing.

(5) Supercharger Drain Valve: (a) A drain passage is provided from the lower rear portion of the supercharger inlet chamber to the bottom of the supercharger rear housing to prevent the accumulation of excess fuel. A check valve drops by gravity when the engine is not running to allow drainage of the excess fuel to the atmosphere. When the engine is running, the check valve is pulled into its seat by the suction in the passage and prevents air from entering the chamber. A restricted air bleed is provided, however, through a small diameter "gurgle" tube that leads up through he drain passage to the mouth of the impeller. During engine operation, any fuel that runs down the walls of the induction passage is prevented from draining to the atmosphere by the closed check valve and is drawn into four holes drilled at the base of the gurgle tube above the air bleed where it is atomized and delivered to the impeller.

(b) Engines equipped with turbo superchargers, as are the Model R-1820-65 and -73 engines, use a special supercharger drain valve assembly. This drain valve differs in operation from the conventional type of drain valve only when the pressure in the induction passage at the mouth of the impeller is at or above atmospheric pressure. These conditions exist when the turbo supercharger is in operation. Under these conditions, there is little or no suction retaining the disc valve in its seat, and the disc tends to drop, thus opening the drain valve to the atmosphere. At this point, manifold pressure acts on a piston fixed to the top of the disc valve to break the remaining suction on the disc and to press it firmly against the outlet flange in the drain valve body, thereby sealing the drain valve against atmospheric pressure. For this purpose, the manifold pressure is conducted from the distribution chamber, through drilled passages in the supercharger rear housing wall, and through the drain valve body to the top of the piston. The mixture at manifold pressure also proceeds through a ball check valve opposite the piston and passes through the jet into the gurgle tube, drawing with it atomized fuel. This mixture issues at the mouth of the impeller where at all times the pressure is less than manifold pressure.

k. Two-Speed Supercharger Drive (Roller Clutch Type). - (1) The Model R-1820-87 engine incorporates a two-speed supercharger which is actuated through the use of a roller clutch assembly. This assembly replaces the impeller drive gear and integral pinion used in single speed engines. In the roller clutch assembly, two separate gears correspond to the dual impeller drive gear of single speed engines, namely, the impeller drive gear, and the intermediate impeller drive gear. These gears are connected through the use of a cam and roller assembly for low speed operation, and by means of a stationary hydraulic multi-plate clutch assembly and a planetary gear system for high speed operation.

(2) The cam and roller assembly includes a steel retainer, ten steel rollers and a steel cam. The retainer is bell-shaped and acts as an outer race for the ten steel rollers which are retained in position by a bronze cage. The hub of the retainer is splined to the intermediate impeller drive gear. The cam is splined on its inside diameter to the intermediate impeller driveshaft, and it acts as an inner race for the ten rollers.

(3) The stationary hydraulic multi-plate clutch is located in a recess in the front face of the supercharger rear housing cover. A piston, fitted with an oil seal ring, operates in a steel sleeve pressed in the rear cover. Splines on the lower portion of the piston mate with similar splines in the sleeve. Forward of the pistons are four friction discs which are splined on their inside diameters to an adapter which, in turn, is splined to the intermediate impeller driveshaft. The discs are separated by three steel plates which spline on their outside diameters to the clutch housing. The housing is secured to the rear cover by studs, washers, nuts and cotterpins.

(4) Oil pressure back of the piston presses the discs and plates against the clutch housing, thereby holding the intermediate impeller shaft stationary by means of friction existing between the clutch plates and discs. The clutch is released by allowing the oil to drain from behind the piston. Release of the clutch is also aided by a coil spring which is compressed between the piston and clutch housing at assembly, and which exerts a constant backward pressure on the piston. When the clutch is disengaged, the steel plates which are splined to the clutch housing remain stationary, and the friction discs are allowed to rotate with the intermediate impeller driveshaft to which they are splined.

(5) The planetary gear system operates inside the impeller drive gear which has internal teeth cut on its inside diameter. This internal gear acts as the bell gear for the planetary system which includes four pinions that ride in a cage and mesh with a sun gear which is integral with the intermediate impeller driveshaft. The cage is split through the center and is held together by two indexing pins and by four capscrews. The rear half of the cage is splined to the intermediate impeller drive gear.

(6) The clutch is controlled by a push-pull selector valve which connects corresponding oil passages to provide oil pressure behind the hydraulic clutch piston, or to cause this oil to drain. When the hydraulic clutch is engaged, it holds the intermediate impeller driveshaft stationary, causing the planetary gear drive to become effective, and thereby producing high speed operation. When the hydraulic plate clutch is disengaged, all supercharger operation is effected through the cam and roller assembly which produces the low ratio speed.

(7) For low speed operation, the impeller drive is obtained from the accessory drive gear through the intermediate impeller drive gear to which both the roller retainer and the planetary pinion cage are splined. A reaction in the planetary system causes the rollers to become wedged between the cam surface and the retainer, causing the movable parts of the clutch to lock and turn as a unit, the resulting drive is similar to the single speed supercharger drive. The following parts form this driving unit: The intermediate impeller drive gear; the retainer, which is splined to this gear; the cam, which is locked to the retainer by the wedged rollers; the intermediate impeller driveshaft to which the cam is splined, (and its integral sun gear); the pinion cage, which is splined to the intermediate impeller drive gear; the planetary pinions, which are held stationary by the fixed sun gear and cage; and the impeller drive gear, which is held fixed in the unit by the stationary pinions.

(8) High ratio operation is obtained when the engaged hydraulic clutch holds the following parts stationary: the intermediate impeller shaft and its integral sun gear, and the roller clutch cam which is splined to the shaft. Under these conditions, the impeller is driven by the accessory drive gear, through the intermediate impeller drive gear to which the pinion cage is splined, and through the planetary system and impeller drive gear to the impeller shaft gear. During high ratio clutch operation, the roller clutch becomes ineffective since the motion of the retainer relative to the fixed condition of the cam causes the rollers to be located on the low levels of the cam surface.

1. Ignition. - (1) Ignition is supplied by two Scintilla SF-9L-4 magnetos attached to the supercharger rear cover. The magnetos incorporate nine lobe breaker point cams which turn at 1/2 crankshaft speed. The pivotless type breaker points are employed. Both magnetos are timed in No. 1 cylinder after which they operate with fixed timing. The right hand magneto fires the front spark plugs and the left hand magneto fires the rear spark plugs. Section VIII of this Handbook gives timing instructions and T. O. No. 03-5DA-2 contains complete information on the Scintilla SF-9L-4 magneto.

(2) The ignition wire is rubber insulated and covered to prevent wear and deterioration. A manifold extending around the outside of the crankcase front section at the parting surface conducts the ignition leads to the front and rear spark plugs of each cylinder. All parts of the ignition wire assembly are shielded to eliminate radio interference.

(3) The R-1820-65, -73, and -97 engines may be equipped with either Aero LS38C or Champion C34S spark plugs. The R-1820-71 engines come equipped with BG-298GS spark plugs and the R-1820-87 engines with Champion C34S or A.C. LS85 spark plugs. The Aero LS38C and the Champion C34S and A.C. LS85 plugs are threaded to receive 5/8" terminal elbows, while the BG-298GS plugs take 9/16" terminal elbows. Complete information on the servicing of these spark plugs may be found in T. O. No. 03-5E-1.

m. Carburetion. - The R-1820-65, -73 and -97 engines are equipped with Bendix Stromberg PD-12H2 Injection carburetors and the R-1820-71 and -87 engines with Bendix Stromberg PD-12H3 Injection carburetors. Operating instructions and further information may be found in T. O. No. 02-35GC-1 and T. O. No. 03-10BA-2.

n. Air Deflectors. - Pressure type, close fitting cylinder head and barrel baffles of sheet aluminum alloy are used to direct the flow of air through the cooling fins with maximum efficiency.

o. Crankcase Breather. - (1) R-1820-65, -71, -73, and -97 engines breathe entirely through the cored passages in the supercharger front housing as previously mentioned in this section.

(2) Crankcase vapors enter the sump through the crankcase oil drain holes, where they pass around a ribbed section and out of a port in the right arm of the sump. Leaving the sump the vapors pass through a cored passage around the rim of the supercharger front housing. Arriving at the top of this passage, the vapors pass into the atmosphere through an outlet which is secured to the top of the supercharger front housing.

(3) A spring loaded relief valve located in the upper section of the cored passage opens to give the crankcase vapors a short direct route to the atmosphere in the event abnormal pressure builds up in the crankcase. This is a flat steel disc valve which seats in a bronze insert screwed into the passage front wall section. The aluminum alloy plugs installed in the front wall section are installed for manufacturing reasons and have no bearing on the breather system.

*(4) The model R-1820-87 engines breathe through the crankshaft. They incorporate a breather tube and an adapter inside the hollow propeller shaft to provide a direct passage for the crankcase vapors to the atmosphere. Refer to paragraph 2.d.(9) of this section for further information. On these engines, the crankcase breather outlet is blanked off with a crankcase breather substituting cover.

p. Lubrication. - (1) General: The lubrication system is of the full pressure dry sump type, in which all moving parts are under oil pressure except the cylinder walls, piston pins, crankshaft roller and ball bearings, which are lubricated by splash. The Limits and Lubrication Charts of T. O. No. 02-35-1 should be referred to, along with the description of the lubrication system outlined in this paragraph.

(2) Oil Pump: (a) The oil is drawn from and returned to an external oil supply tank by an oil pump assembly mounted on the lower left side of the supercharger rear cover. The pump consists of a cast aluminum alloy body with cored passages for two sections accommodating a separate pressure and scavenge pump located at the rear and front of the pump body respectively. Both pumps consist of two spur gears with large teeth, the scavenge pump gears being longer than those of the pressure pump. The drive is effected through a shaft milled with scavenge gear teeth and splined at both ends. This shaft is located in the approximate center of the gear section with the front end extending through an end plate to mesh with the oil pump drive in the rear supercharger housing cover by means of a splined coupling. The pressure pump drive gear, located at the rear of the body, is splined to the rear end of the oil pump drive shaft. A mating idler gear meshes with each of the drive gears of both the pressure and scavenge pumps. Covers at each end of the pump body retain and support the gears. Short hollow steel dowels align the end plates to the body. The front end plate is drilled with two large diameter holes which line up with similar holes in the supercharger rear housing cover to form the inlet and outlet passages for the oil pump. Provision is made for the flanged inlet and outlet connections with the outlet slightly below the inlet for accessibility. Two oil inlet and one oil outlet temperature connections are also provided. Two spring loaded valves located in the outlet passage of the pressure pump are treated in subsequent paragraphs.

(b) Oil enters the left hand pump connection, passes up through the cored inlet passage, enters the pressure pump gears at the bottom, is carried around in the spaces between the gear teeth, and is discharged into a pocket shaped chamber at the top of the gears. From this pocket the oil has two possible outlets, both of which are controlled by spring loaded, piston type, relief valves.

(c) The oil inlet check valve. All oil entering the engine must pass through this valve. The spring tension, which is not adjustable, is designed to keep the valve closed against the gravity head of oil in the supply tank when the engine is stopped, and to open with very little restriction when the engine is running. The valve assembly is retained in a bronze sleeve which is screwed into the oil pump body, and over which a steel cap is screwed. The alloy steel piston is spring loaded and accommodates one bronze piston ring. When the engine is running, end movement of the piston uncovers ports in the sleeve through which the oil passes to the engine. Displaced air and oil leakage is vented through a drilled passage into the supercharger rear housing cover and housing. An oil pump check valve was found to be unnecessary in the Model R-1820-87 engine and was replaced with a substituting plug.

(d) The oil pressure relief valve. This valve is incorporated in the oil inlet to provide a means of pressure regulation. It consists of a bronze alloy body containing a nickel steel piston with a flat seat. The spring tension may be varied by turning an adjusting screw on the rear of the body. A steel locknut and a steel cap, screwed on the outside diameter of the adjusting screw, keeps the screw from loosening, and prevents oil leakage. The bronze retaining body is screwed into the oil pump body. When the oil pressure in the pocket shaped chamber of the oil pump body exceeds the spring tension, set by regulation of the adjusting screw, the piston slides back and uncovers ports in the bronze body through which excess oil bypasses into the cored oil inlet passage at the entrance to the

pressure pump gears. Turning the adjusting screw in a clockwise direction increases the spring tension and the engine oil pressure. Anti-clockwise movement of the adjusting screw produces the opposite effect. Displaced air and oil leaking around the piston passes through a hole drilled in the adjusting screw into the dome of the retaining cap. The cap and locknut have a groove milled lengthwise in their internal threads, through which the dome of the retaining cap is vented to the oil pump body, where a drilled passage discharges the displaced oil and air into the supercharger rear housing.

(3) The Cuno Automatic Filter: (a) After leaving the oil pump the oil flows through a hole drilled in the supercharger rear cover. Passing through the rear cover, the oil fills an annular chamber surrounding the Cuno automatic filter.

(b) The filter consists of a cartridge filter unit made up of closely spaced discs separated by cleaner blades, and a small hydraulic motor to provide continuous rotation of the cartridge. The cleaner blades remain stationary and impart a combing action to the discs which turn at approximately one to two RPM under normal operating conditions. The motor operates on a very little amount of the filtered oil, is self starting, and remains in operation as long as the lubrication system is under pressure. The oil used by the motor returns to the engine lubricating system. A pinion shaft is provided to turn the cartridge manually for inspection or test purposes. A spring loaded ball pressure relief valve is incorporated in the filter to allow the oil to bypass the oil filter in the event the oil is cold and viscous or the unit becomes clogged.

(c) The inner end of the filter cartridge is a light press fit in the accessory drive and starter shaft supporting boss of the supercharger rear housing. The oil is forced into the hollow center of the filter either through the closely spaced discs or through the pressure relief valve, where it is conducted to the inner end of the filter, and through an annulus surrounding the bronze accessory drive and starter shaft supporting bushing. At this point the oil is subject to its first division, with the major quantity of oil continuing through the engine, and the remainder lubricating the accessory drives in the supercharger rear housing cover. For more complete information on this filter, refer to T. O. No. 02-1-24.

(4) Supercharger Rear Housing Cover Lubrication: (a) The front face of the rear cover is cast with four ribbed sections extending radially from the accessory drive and starter shaft supporting boss. These ribbed sections are drilled to conduct the oil to the accessory drive bushings from the annulus around the accessory drive and starter shaft. A tube extending from the top of the accessory drive and starter shaft supporting boss conducts oil to a pressure gage connection at the upper right hand section of the cover.

(b) The two upper drilled ribbed sections supply oil to a groove around the outside diameter of each magneto shaft bushing. The upper portion of each magneto shaft bushing is milled away for the installation of the gun synchronizer supports. The milled away portions uncover the oil grooves of the magneto shaft bushing in two locations, through which oil issues to lubricate the gun synchronizers and the inside diameter of the magneto shaft bushings. The inner gun synchronizer supporting bushing is provided with grooves in its inside diameter, through which oil enters the support to lubricate the outer bushing and the synchronizer mechanism. Holes drilled in the outer flanged section of the gun synchronizer support drain the surplus oil into the supercharger rear housing.

(c) The lower right hand drilled passage provides oil to a groove around the outside diameter of the spare drive bushing. This bushing is milled away in a similar manner to the magneto bushings, to accommodate the fuel pump support and uncovering the oil groove at two points. Oil issuing out of the two openings supplies lubrication to the inside diameter of the spare drive bushing and enters the fuel pump drive shaft support through grooves cut in the inside diameter of the inner shaft supporting bushing. The oil fills the support and lubricates the outer shaft supporting bushing. Surplus oil is drained back into the supercharger rear housing through holes drilled in the support near its outer flange. A passage is drilled angularly through the supercharger rear housing cover from rear to front at the spare drive mounting pad, communicating with an oil groove opening at the spare drive shaft bushing. Oil under pressure travels through this passage to lubricate the dual spare drive gear box and accessories requiring engine oil for lubrication. A complete description of the dual (spare) accessory drive housing lubrication is found in this section.

(d) Oil from the lower left hand drilled passage enters the inside diameter of the oil pump shaft bushing through a hole drilled in a groove extending around the outside diameter of the bushing at its front end. A groove in the inside diameter of the bushing distributes the oil along its length. A circumferential groove and drilled hole is provided at both ends of the bushings so it cannot be installed incorrectly.

(e) A ribbed section between the oil pump drive shaft supporting boss and the generator drive shaft supporting boss forms an integral part of the front face of the supercharger rear housing cover casting. A branch passage is drilled through this section intersecting the oil pressure passage to the oil pump drive shaft bushing. Oil is supplied to a groove in the outside diameter of the generator shaft bushing through this branch passage. The groove is drilled with holes to lubricate the inside diameter of the bushing. The supercharger rear housing cover is drilled from front to rear at the left hand side of the generator mount pad to communicate with the branch oil pressure passage for supplying the generator, or accessory with engine oil if desired.

(f) The accessory drive gears run in a bath of oil which is constantly being forced out the ends of their shaft supporting bushings. To prevent the external leakage of oil, the following types of oil seals are employed.

Accessory Drive	Seal Type
Starter and Accessory Drive Shaft	Spherical oil seal ring of oilite material
Generator and Magneto Drives	Spring loaded neoprene diaphragm
Fuel Pump Drive Shaft	Leather seal reinforced with coiled spring
Tachometer Drives	Plunger loaded neoprene packing rings

(g) The supercharger rear housing cover is drilled at the base of a recess behind each accessory drive shaft bushing to drain the surplus oil into the supercharger rear housing. The magneto, oil pump, and spare drive shaft recesses have one drain hole each. The generator drive shaft has three drain holes, while the accessory drive and starter shaft has two internal drain holes and provision for one external drain at the lower right hand side of the mount pad.

(5) Crankshaft and Cylinder Lubrication: (a) The major quantity of oil arriving at the accessory drive and starter shaft bushing annulus, passes through slots in the bushing and enters the hollow accessory drive and starter shaft through holes in its rear journal and holes in the hollow aluminum oil seal spacer. Some oil is forced into the inside diameter of the slotted accessory drive and starter shaft bushing, and is distributed over the front face of the bushing shoulder by shallow grooves. In passing through the accessory drive and starter shaft, some of the oil is forced through a hole drilled in the shaft near its front end and fills the annulus formed between the accessory drive and starter shaft and the impeller drive shaft. Oil flats are provided on the accessory drive and starter shaft outer diameter to distribute oil over the entire length of each impeller shaft supporting bushing. From the accessory drive and starter shaft the oil enters a recess in the rear counterweight crankcheek.

(b) A hole drilled through the rear crankcheek and into the crankpin conducts the oil into the center of the hollow crankpin. A tube extending into the hollow crankpin conducts some of the oil to flats milled on the crankpin. The flats distribute oil over the surface of the crankpin for the master rod bearing to ride on. The oil enters an annulus in the knuckle pin lockplate and is conducted through holes drilled in the knuckle pin lockplate tabs to the knuckle pin locking screws. The oil enters holes drilled in the front of the knuckle pin locking screws and fills the hollow centers of the knuckle pins. Two holes drilled 180° apart in each knuckle pin conduct the oil to the outside diameter of the pin where two flats distribute the oil over the knuckle pin bushings in the articulated rods.

(c) A passage is drilled through the top center of the crankpin at its rear end to supply adequate lubrication for the cylinder walls, piston pins, and roller bearings. Oil is conducted through drilled passages in the rear crankcheek from the recess at the rear of the crankcheek to an annulus surrounding the floating damper pin bushings. An oil jet screwed into the front end of the crankpin also supplies lubrication for the cylinder walls, piston pins and roller bearings. The motion of the crankshaft and connecting rods assures effective splash distribution.

(d) The oil is led from the crankpin through a drilled passage in the front crankcheek to the hollow driveshaft. Here it acts as a header for various indexing passages through which the cam and valve operating mechanism and the reduction gear assembly are lubricated. This reservoir also supplies oil to the propeller governor. In engines which incorporate crankshaft breathing, this oil reservoir is located in the annulus formed between the breather tube and the driveshaft.

(6) Reduction Gear Lubrication: (a) From the reservoir in the hollow crankshaft the oil takes the following paths:

1. Through a hole drilled in the wall section of the crankshaft to a hole drilled through the wall section of the propeller shaft to supply oil to the propeller governor pump and lubricate the reduction gear.

2. Around the front end of the crankshaft to lubricate the propeller shaft front bushing by means of a flat on the surface of the crankshaft.

3. Through an adapter into a distributor valve to supply hydro low pressure oil for operating a hydromatic propeller. Note that if an electric or test propeller is used, this passage is blanked off.

4. Under 1. above, the oil is distributed over the inside diameter of the propeller shaft rear supporting bushing by a flat on the surface of the crankshaft. Oil escaping out of the front end of the bushing travels along the crankshaft outside diameter in the annular space between the crankshaft and the propeller shaft internal sleeve to join the oil following the path described in 2. above, thus keeping both propeller shaft supporting bushings under pressure lubrication.

5. The major quantity of oil described in 1. above, enters a circumferential groove on the inside diameter of the propeller shaft rear supporting bushing. Two oil systems originate at this groove, the first of which supplies oil for the propeller governor and the second for the reduction gear assemblies.

a. The lubrication of the propeller governor is described in paragraph 2.p.(8)(a) of this section.

b. Lubrication of the R-1820-65 and -97 - .5625 (16:9) ratio reduction gearing is as follows:

(1) Oil is supplied to longitudinal grooves on the outside diameter of the propeller shaft rear supporting bushing through radially drilled holes equally spaced around the bushing. The oil flows back along the longitudinal grooves into a circumferential groove on the outside diameter of the bushing. This groove lines up with the drilled passages in the propeller shaft pinion supporting flange to conduct the oil to an annulus formed between the rim of the flange and the attached pinion carrier ring. From this annulus the oil enters the annular spaces around the twenty necked pinion retaining bolts through twenty drilled holes in the carrier ring. The oil is fed to the floating pinion bushings by two radially drilled passages in each pinion supporting trunnion. The passages are 90° apart facing the leading side of each trunnion and are interconnected by a circumferential groove. The floating pinion supporting bushings are drilled with six holes to supply ample lubrication to both sides of the bushing. Surplus oil escaping from the ends of the bushing, provides a bath of oil for the planetary reduction gear teeth.

c. Lubrication of the R-1820-71, -73, and -87 - .666 (3:2) reduction gearing is as follows:

(1) The oil is supplied to longitudinal grooves on the propeller shaft rear supporting bushing in a similar manner as described in paragraph b.(1) above; however from the circumferential groove on the ourside diameter of the propeller shaft rear supporting bearing, the oil is led to a hole drilled in each of the six spider arms on the propeller shaft. The oil is fed through these passages into a groove in each spider arm bushing. From these grooves the oil passes through drilled holes in the pinions into the annulus formed between the inside diameter of the pinion and the lock nut. Another drilled hole leads the oil from this annulus back to the bushing in the spider arm.

(7) Cam and Cam Drive Gear Lubrication: (a) A second drilled passage in the crankshaft at the reduction driving gear spacer forms a second oil system which lubricates the cam and cam drive mechanism.

(b) The oil is conducted from the crankshaft to the spacer through six drilled passages in the spacer. These six drilled passages communicate with an annulus in the front main roller bearing retainer ring. Three holes drilled in the cam bearing hub connect the oil from the annulus to lubricate the cam hub bearing.

(c) A drilled passage in the cam drive and pinion gear bracket intersects the passage leading oil to the cam hub bearing, and supplies lubrication to the cam drive and pinion gear bushing through a hole drilled in the bushing and a flap on the cam drive and pinion gear shaft. Leakage from the bushing supplies lubrication for the cam gear teeth and the cam follower rollers.

(8) Valve Gear Lubrication: (a) Oil to the propeller governor pump originates in the passage described in paragraph 2.p.(6), of this section. The oil passes through a drilled passage in the stationary reduction gear and through indexing passages in the crankcase front section to the governor mounting pad. This passage may be blocked off by an aluminum cover plate when a governor pump is not used.

NOTE: The model R-1820-97 engine and some R-1820-65 engines also incorporate an external governor oil supply line leading from the left hand gun synchronizer impulse generator location on the supercharger rear housing, through the intercylinder air deflector between cylinders Nos. 8 and 9, to the low pressure governor oil supply passage in the crankcase front section. For a more complete description of this installation refer to T. O. No. 02-35GC-3.

(b) A passage intersecting the low pressure governor pump oil supply passage conducts the oil to an annulus surrounding the governor drive bushing, lubricating the bushing.

(c) A drilled passage intersecting the annulus around the governor drive shaft bushing connects with a channel machined into the shoulder of the rear surface of the crankcase front section. This channel is sealed by a rubber channel oil seal ring between the crankcase front main section.

(d) Drilled passages leading from the channel section supply oil to the eight valve tappet assemblies above the horizontal engine centerline. Lubrication of the eight upper valve tappet assemblies is accomplished as follows:

1. Oil is metered into the hollow valve tappet every time a drilled hole in the reciprocating tappet coincides with the valve tappet guide. Surplus oil lubricates the inside diameter of the guide, tappet roller, hub, pin, and cam lobes.

2. The oil is forced into the hollow push rods through indexing holes in the inner ball ends and the spring loaded valve tappet socket.

3. The oil enters the valve clearance adjusting screw through indexing holes in the push rod outer ball ends and the socket end of the adjusting screw. The screw is drilled with three radial passages intersecting the index hole in the cup end of the adjusting screw, through which oil is delivered to a groove in the rocker arm threads.

4. From the groove, the oil is forced through a drilled passage in the rocker arm through an annulus formed by the outer race retaining clip in the tapered roller bearing. Oil lubricates the bearing and escapes out its ends to supply lubrication to the rocker roller and valve stem.

5. Excess oil drains down the inside of the push rod housing and is returned to the engine crankcase through an angularly drilled passage in the valve tappet guide which aligns with a spotfaced corner of the tappet roller slot in the crankcase.

6. The following rocker assemblies are lubricated by pressure oil feed:

Cylinder No. 1, 2 and 9, both intake and exhaust; Cylinder No. 3 - exhaust; Cylinder No. 8 - intake.

7. The rocker assemblies below the horizontal engine centerline are lubricated by oil seeping through the clearance between each valve tappet and its guide, after which it runs down the inside of the push rod housing and fills the rocker box. The desired quantity of gravity fed oil for this purpose is obtained by controlling the valve tappet diametrical clearance in their guides.

(9) Two-Speed Roller Clutch Lubrication (R-1820-87): (a) The oil for lubricating the supercharger clutch drives is taken from the oil passage connecting the groove around the generator drive shaft bushing. This oil is conducted through a small drilled passage in the rear cover to an annulus around the supercharger control valve.

(b) From this point, some of the oil flows through a drilled passage to the annulus around the rear end of the intermediate impeller shaft rear bushing and through the hollow shaft. At the approximate center of the intermediate impeller shaft some of the oil flows through three drilled passages to lubricate the intermediate impeller drive gear bushing and journal. The remaining oil continues through the hollow shaft and out the propeller end to lubricate the front bushing and journal, and the bushing and journal of the impeller shaft drive gear. This oil is also led through drilled passages to lubricate the intermediate impeller drive pinion gears and bushings.

(c) The remaining lubricating oil that does not flow to the hollow intermediate impeller drive shaft from the annulus around the supercharger clutch oil control valve shaft, flows through another drilled passage to lubricate the intermediate impeller drive shaft rear bushing and journal.

(d) The oil for operating the high ratio supercharger clutch drive is also provided from the annulus around the supercharger clutch oil control valve sleeve. This pressure oil is obtained by moving the supercharger clutch oil control valve to the rearward or "out" position. This allows the engine pressure oil to flow around the annulus cut in the supercharger clutch control valve, to a drilled passage in the control valve sleeve, and through a mating drilled passage in the rear cover, to the chamber behind the high ratio supercharger clutch piston.

(e) When the supercharger clutch oil control valve is shifted back to the low ratio supercharger clutch drive position, it blanks off the pressure oil passages to the chamber behind the high ratio supercharger clutch piston, and opens oil drain passages through the valve and the rear cover, thus releasing the pressure oil in the chamber behind the high ratio supercharger clutch piston. This releases the supercharger clutch piston, discs, and plates with the aid of the impeller clutch release spring.

(10) Dual Accessory Drive Lubrication: (a) As described in paragraph 2.c. (4) of this section, the supercharger rear housing cover is drilled just above the spare drive shaft to supply pressure for lubricating the dual spare drive gear box, and accessories mounted thereon requiring engine oil for lubrication.

(b) When the dual spare drive assembly is installed two pipe plugs are removed from the supercharger rear cover and one plug from the dual spare drive housing. Refer to the installation drawing. All the bushings in the spare drive assembly are pressure fed, with the surplus oil providing a bath for the gears, after which it is drained into the supercharger rear housing through the unplugged hole in the dual spare drive housing which indexes with one of the uncovered holes in the supercharger rear housing cover. Pressure oil passages are drilled in the dual spare drive housing cover to supply accessories requiring engine oil for lubrication. The Engine Installation Drawing should be referred to for information on which plugs to remove for external drainage when using other types of oil.

(c) Engine oil under pressure enters the upper left hand side of the dual spare drive housing through a drilled passage which indexes with the supply passage in the rear supercharger housing cover. This passage extends through the housing to the parting flange where an indexing hole in the dual spare drive housing cover conducts the oil into the cover passages so that both housing and cover receive oil from the same source of supply.

(d) Ribbed sections of the dual spare drive housing and cover are drilled to supply oil to the four bushings in each, but as the systems are slightly different, the housing and cover will be treated separately.

1. In the housing, oil is conducted from the drilled supply passage through a short passage to an annulus around the copper-lead main drive gear front bushing in the upper left hand corner. The bushing is lubricated through two drilled holes and the remainder of the oil is delivered to an annulus around the center copper-lead bushing. This bushing is lubricated through three holes and the remainder of the oil takes two paths, both of which terminate in an annulus around the

two remaining bushings in the housing. The upper right hand bushing is lubricated through two holes and the surplus oil drains through a drilled passage at the front end of the bushing. The lower oilite bushing needs no drilled holes because of its porous structure. Surplus oil is likewise drained through a drilled hole at its front end.

2. In the dual spare drive housing cover, oil is conducted from the drilled supply passage into an annulus around the main drive gear bushing in the upper left hand corner. The bushing is lubricated through three holes and the remainder of the oil takes two paths: to an annulus around the upper right hand spare drive bushing and an annulus around the central bushing. The upper right hand bushing is of oilite material and needs no oil holes. The annulus around this bushing is intersected by a drilled passage for pressure feed to an accessory. The central bushing is lubricated through drilled holes and the remainder of the oil takes an irregular passage to an annulus around the lower spare drive bushing. This passage is irregular because it is made up of two drilled legs, at the junction of which a hole is drilled to supply oil to an accessory. The lower spare drive bushing is of undrilled oilite material.

(e) A cast magnesium adapter plate may be installed on the lower drive to accommodate an accessory with the same stud spacing as the upper drive. This is drilled with an oil passage which has a hole on its front face indexing with the accessory supply passage on the lower drive mount pad, and an outlet on its rear face at a corresponding location to the upper drive accessory supply passage.

(11) Scavenge System: (a) All of the oil in the lubrication system drains into an oil sump located between No. 5 and 6 cylinders. The crankcase front section drains through a large hole in the section directly into the sump at its forward end. The crankcase main section drains into flange channels in the main case. The front channel drains the oil into the crankcase front section through two short tubes in the front section, where it meets the front section drainage and passes into the sump. The rear channel in the crankcase main section drains into an escape outlet in the supercharger front section which drains into the left hole of the two large holes drilled in the left arm of the sump. Oil draining from the accessory gearing in the supercharger rear housing drains into the same hole in the supercharger front housing. The engine breathes through the hole in the right arm of the sump as described in paragraph 2.n. of this section.

(b) All oil being removed from the sump by the engine scavenge pump first passes through a removable cylindrical screen of twelve mesh per inch brass wire. The oil is then drawn by the scavenge pump through the large right hand hole of the left arm of the sump. This hole mates with a cored passage in the supercharger front and rear housings which communicate with a drilled passage in the supercharger rear housing cover. A hole drilled in the oil pump body end plate lines up with the hole in the cover and delivers the oil to the scavenge pump gears which discharge into the external oil tank.

(c) R-1820-97 engines also incorporate an external oil scavenge line, leading from the oil sump strainer to the oil pump. For more complete description of this installation refer to the Handbook of Overhaul Instructions, T. O. No. 02-35GC-3.

q. Priming System. - (1) Prior to and during the period of starting engines equipped with Bendix-Stromberg injection carburetors, it is necessary to provide a supply of fuel to the cylinders from some source other than the carburetor. This is accomplished by a priming system which consists of an auxiliary pump and feeder line in the airplane supplying fuel to a distributor, from which the fuel is conducted through tubes and injected into the upper cylinders.

(2) The priming distributor is clamped to the approximate midpoint of the No. 1 cylinder intake pipe. The priming system supply line enters the top of the distributor and five brass nipples are screwed radially into the periphery of the distributor body, providing spherical seat connections for the steel priming tubes. The tubes are secured to the intake pipes by clips and are encircled at the clip locations by heat and oil resistant rubber bushings to protect the tubes and to absorb vibration. 90° brass attaching nipples are screwed into the intake ports and provide spherical seat connections for the priming tubes. Each nipple is provided with an outlet jet which discharges the priming fuel into the intake port in the form of a fine spray.

(3) Refer to T. O. No. 02-1-29 for operation of the primer.

SECTION IV

PACKING & UNPACKING

1. Shipping Boxes, Domestic and Overseas

a. General Construction - Shipping boxes for these engines are constructed in two sections consisting of a cradle on which the engine is mounted and in which unattached parts are stored, and a cover which is bolted to the cradle. Both the cover and the cradle are constructed of sound pine or spruce wood with the cradle extending for approximately 1/4 of the total box height. Cradle members of 2 3/4" thickness are bolted to the bottom of the box with through bolts to form a support for a rugged steel mount plate which is attached to the mounting lug section of the engine. The sides and top of the box are constructed of single ply matched tongue and groove 7/8" board, amply reinforced with cross strips of the same thickness. The box rests on two skids of 2 3/4" thickness bolted to its bottom, which is constructed of double ply matched 7/8" boards. Two steel straps on each of two opposite sides of the cover form lifting hooks and provide means of bolting the cover to the cradle section. The cradle bottom outside corners are reinforced with angle iron. The cradle is painted all over and the cover on the external surfaces.

b. Comparison of Domestic and Overseas Boxes. - (1) Domestic and overseas shipping boxes have the same overall dimensions.

(2) Both have a layer of 3 ply asphalt felt between the bottom boards, and around the inside of the cradle walls.

(3) The cover of the overseas box is lined with 3 ply asphalt felt while the domestic box is unlined.

(4) The top of the overseas box is metalclad all over with sheet iron whereas the domestic box has two sheet metal guards only, at the upper corners to protect the wood against the lifting tackle.

c. Dimensions and Weights. - (1) The dimensions of the shipping boxes for these engines are as follows:

LENGTH	70 inches
WIDTH	61 inches
HEIGHT	58 inches

(2) The approximate total weight of the domestic shipping box with the engine packed for shipment is 2090 lbs.

(3) The total overseas shipping weight is approximately 50 lbs. heavier than the domestic weight.

2. Preparation of Engine for Packing

a. Unless it is to be installed for operation in an airplane within 48 hours, each engine shall be prepared for storage prior to being packed in an engine shipping box. The preparation and subsequent treatments shall be done in accordance with T. O. No. 02-1-1 with the following additions:

(1) After completing any running with fuel containing tetra-ethyl lead, the engine shall be operated for 1/2 hour with unleaded fuel before preparation for storage or shipment.

(2) With the engine in the horizontal or normal flight position remove the oil sump screen and magnetic drain plug. Allow the sump to drain. Inspect for foreign material and wash screen and plug in clear unleaded gasoline. Slush the screen and plug in corrosion-preventive compound, Spec. 3568 and install in sump.

(3) Remove the Cuno automatic filter and inspect for foreign material on the filter unit. Wash the filter thoroughly in a 50:50 mixture of benzol and clear unleaded gasoline, using the reversible nut to turn the filter element. Dip the filter unit in compound, Spec. 3568, but do not install in engine at this time.

(4) Remove the starter, generator, and accessories on the dual spare drive, or cover plates over any of the above locations. Remove the gun synchronizers and supports from the rear supercharger housing. Remove the fuel pump. Remove the oil tank vent fitting from the supercharger rear housing cover. Thoroughly slush all parts in the interior of the supercharger rear housing with compound, Spec. 3568, by inserting the nozzle of the spray to thoroughly slush the accessory drive gear. Lightly spray the tailshaft and generator drive recesses in the raised portion of the supercharger rear housing cover, and also the two drives on the dual spare drive housing.

(5) T. O. No. 02-1-14 contains information as to which accessories are to be included with the engine. Such accessories should be slushed externally with melted petrolatum, Spec. AN-VV-P-236, wrapped in oiled paper, and covered with heavy wrapping paper. Install cover plates over the accessory drive mount pads, tightening all nuts and palnuts. Remove the four fuel pump housing attaching studs and install a dummy fuel pump drive shaft support with capscrews. Install dummy gun synchronizer supports

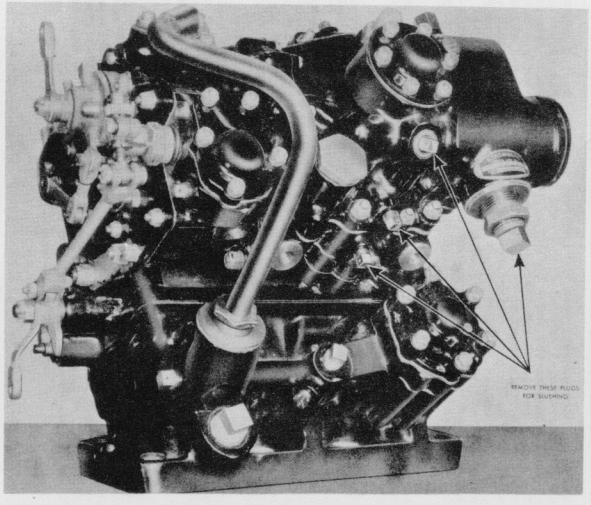

FIG. 4 - GUIDE FOR SLUSHING CARBURETOR

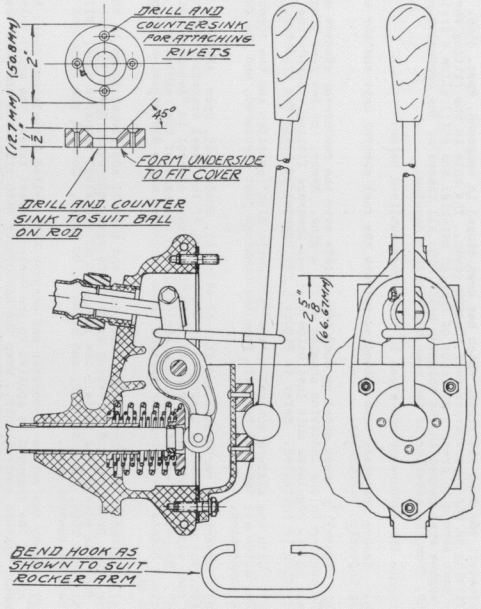
DRILL AND COUNTERSINK FOR ATTACHING RIVETS
2" (50.8mm)
½" (12.7mm)
45°
FORM UNDERSIDE TO FIT COVER
DRILL AND COUNTER SINK TO SUIT BALL ON ROD
2.5" (66.67mm)
BEND HOOK AS SHOWN TO SUIT ROCKER ARM

FIG. 5 - MODIFIED ROCKER BOX COVER AND HOOK

with capscrews. Reinstall the Cuno oil filter which has been dipped in compound, Spec. 3568. Reinstall the oil tank-vent fitting on the supercharger rear housing cover. The hole in the fitting should be covered with a fine mesh screen to prevent entrance of foreign material and still allow a drain hole for surplus oil in the engine when packed in the shipping box. Wipe all traces of the corrosion-preventive compound, Spec. 3568, from the exterior of the rear supercharger housing.

(6) Prepare the carburetor and slush in the manner outlined below:

(a) Remove the steel tube extending between the fuel control unit and the adapter of the Bendix-Stromberg Injection carburetor.

(b) Install a sheet metal or wood cover plate over the carburetor adapter mounting pad to blank off the opening to the induction chamber of the engine. Remove the two rear plugs of the three 1/8" pipe plugs in the regulator unit just below the fuel pressure fitting. Remove the plug from the fuel pressure fitting if installed. Refer to Figure 4 for removal of plugs for slushing.

(c) With the mixture control in the "Automatic Rich" position and the throttle in the "Full Open" position, allow all the fuel to drain from the openings just uncovered, and the fuel inlet, outlet and pressure connection.

(d) Invert the carburetor and fill it with oil, Grade 1065, Spec. AN-9532, through the fuel inlet connection, the upper opening uncovered by the removal of the steel transfer tube, and the drain holes in the fuel control and regulator units, with the mixture control in "Automatic Rich" and the throttle "Full Open". Do not put any oil into the air diaphragm chambers of the regulator or automatic mixture control units. Rotate the carburetor several times to insure ample distribution of the oil, and drain out the light oil.

(e) Reinstall the three drain hole plugs and install additional plugs in the fuel inlet, vapor separator, fuel pressure, and air scoop connections using compound, Spec. 3590, on the threads. Drain all the fuel from the adapter and install the lower end of the steel transfer tube. Fill the tube and adapter with oil Grade 1065, Spec. AN-9532, and allow it to drain. Connect the upper end of the fuel transfer tube to the fuel control unit.

(f) Spray the entire carburetor and adapter with melted petrolatum, Spec. AN-VV-P-236, being careful that none of the compound is applied to the venturi impact tubes, the small boost venturi tubes, or the automatic mixture control unit. Wrap the carburetor with oil cloth and pack the assembly solidly in the wood carburetor box provided in the base of the engine shipping box.

(7) Remove the No. 1 cylinder exhaust push rod housing, push rod, tappet guide, and tappet assembly. It will be necessary to loosen No. 1 exhaust rocker arm valve clearance adjusting screw all the way out to its stop and slightly compress the valve spring by forcing the rocker arm down at the valve end to allow removal of the push rod lower end through the slotted tappet guide. Swing the engine on its mounting stand until the No. 1 cylinder exhaust tappet hole faces downward and allow any surplus lubricating oil in the nose section to drain out. Return the engine to a position with the propeller shaft pointing straight down, and pour enough compound, Spec. 3568, into the No. 1 cylinder exhaust tappet hole to fill the nose section to the level of the tappet hole. Swing the engine until the open tappet hole faces downward and allow all of the slushing compound to drain. Swing the engine until the propeller shaft extends vertically upward and reinstall the No. 1 cylinder exhaust tappet and push rod assembly.

(8) All valve stems and guides should be slushed with compound, Spec. 3568, and the movement of the valve is important to insure that the compound is properly worked into the valve guide. Whichever of the following methods that is practicable should be employed.

(a) With the propeller shaft pointing straight up, install modified rocker box covers and gaskets on all cylinders. The modification consists of cutting off the push rod end of 18 discarded covers on line with the rocker arm hub bolt. Install the modified rocker box covers and fill all the rocker boxes to the cutaway edges of the cover with compound, Spec. 3568. Remove the temporarily installed dummy front spark plugs from all cylinders. Remove the plugs from the oil pump inlet and outlet connections. Turn the propeller shaft approximately 125 revolutions, using a turning hub or attaching an air starter to the starter mount pad on the supercharger rear housing cover. Remove the cutaway rocker box covers and allow surplus slushing compound to drain. Spray all surfaces around the outer push rod ball ends with compound, Spec. 3568.

(b) Modify a discarded rocker box cover as described above and make a simple lever and hook of round stock, as shown in Figure 5. Repeat the procedure outlined in the previous paragraph except that the internal slushing compound is worked into one valve guide at a time by actuating the rocker arm with the hook and lever, instead of by turning the propeller shaft. Actuate each rocker arm approximately 60 times.

(9) When the treatment outlined in T. O. No. 02-1-1 with the additions herein is completed, move the engine into a washing booth and clean thoroughly with clear unleaded gasoline until all oil and grease is removed from external surfaces. Dry with an air blast. During the period of washing the engine, exercise care that cleaning fluid is not permitted to run inside the engine, particularly at the thrust bearing location. A cloth wrapped around the propeller shaft and thrust nut will serve to keep the fluid from entering the engine. Cleaning fluid must also be kept away from the magnetos to avoid fire hazard if the crankshaft is turned, as well as pitting of the breaker points.

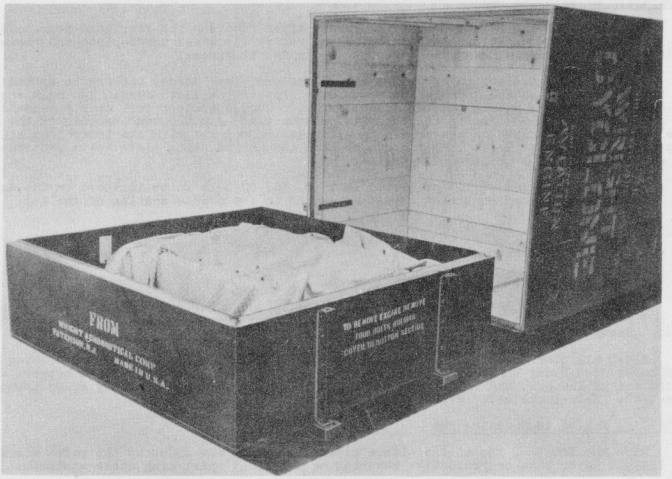

FIG. 6 - SHIPPING BOX PREPARED FOR ENGINE

FIG. 7 - ENGINE WRAPPED FOR SHIPPING

3. Preparation of Shipping Box

a. Lift the shipping box cover off the cradle after removing the four hold-down bolts. Remove the nuts from the ten mount plate attaching bolts and remove the steel mount plate and cross strap from the cradle. Check the remaining cradle structure bolts for tightness.

b. Cut two 16' x 4' lengths of oil cloth. Place one piece across the cradle extending its length parallel to skids on the bottom and placing the glossy side of the cloth down. The ends should extend an equal distance from the cradle and the inner long side should project just over the cradle centerline. Tuck the oil cloth around the cradle structure to provide space for the rear section of the engine. Place the other piece of cloth on the cradle in a similar manner but with its inner long side overlapping the first by a few inches. Break the oilcloth so that the ten mounting plate bolts protrude through. Figure 6 shows shipping box prepared for engine.

c. In addition to the equipment listed in T. O. No. 02-1-14 to be included in the engine shipping box, the following unattached equipment should be packed in the cradle section of the box:

(1) Carburetor assembly

(2) Exhaust flange gaskets (9)

(3) Cylinder head thermocouple

d. Install the wood box in which the carburetor is packed after slushing, as described in paragraph 2. (6) of this section, in the base of the shipping box between a cradle long member and the side of the box. Secure it firmly with wood cleats nailed to box.

e. Slush all other unattached parts with melted petrolatum, Spec. AN-VV-P-236, wrap in oiled paper and cover with heavy wrapping paper. Pack these parts in the space provided between a cradle member and the end of the box, and cover with the board labelled "TOOL BOX", or any sound board 26 3/4" x 12 3/4" x 7/8". Secure the cover with nailed cleats.

4. Installing Engine in Shipping Box

a. Wipe the front of the engine with a clean, dry cloth and touch up the paint wherever it is needed. Install paper bags or protective covering on all front spark plug cable contacts.

b. Attach a hoist eye on the propeller shaft and lift the engine from the movable stand on which it is mounted. Raise it to a height sufficient to make the rear of the engine accessible.

c. Wipe the rear of the engine with a clean, dry cloth and touch up the paint wherever it is needed. Install paper bags or protective covering over all rear spark plug cable contacts. Install a rubber nipple or oil cloth over the supercharger drain valve.

d. Bolt the steel mounting plate to the engine with eight bolts through the mounting lugs on the front supercharger housing. Place washers on each bolt in the following order from rear to front: bolt head, mounting plate, 1 1/4" O.D. plain steel washer, 1 1/4" cushion of thermoid or brake lining material, engine mounting lug section, 1/16" O.D. plain steel washer, and an elastic stop nut on the front end. Tighten all nuts securely.

e. Spray the entire rear of the engine with a light coating of melted petrolatum, Spec. AN-VV-P-236, then lower the engine with mounting plate into the cradle. Assemble cross strap and all nuts and washers on the ten hold-down bolts to secure the mounting plate tightly on the cradle.

f. Remove the propeller shaft lifting eye and spray the interior of the propeller shaft with internal slushing compound, Spec. 3568. Install the protective cap on the front end of the shaft and wipe off any internal slushing compound remaining on the exterior of the shaft or nose section. Spray the entire front of the engine with melted petrolatum, Spec. AN-VV-P-236, and wrap oiled paper around the propeller shaft splines, secured with gummed paper or friction tape.

g. Completely enclose the engine with the oil cloth by carrying the ends tightly around it. Tie a string around the propeller shaft just below the protective cap to bind the upper ends, and secure loose ends with stapling pliers to make a snug enclosure for the engine with the glossy side of the cloth out. Figure 7 shows the engine wrapped for shipment.

h. Lower the shipping box cover over the engine and secure it to the cradle with the four hold-down bolts. Attach "Prepared for Storage" note to box in accordance with " O. No. 02-1-1.

5. Unpacking

a. If the engine was shipped from the factory it will be necessary to break the seals on two of the four shipping box cover hold-down bolts, after which all four bolts and nuts may be removed.

b. Lift off the shipping box cover using the four lifting hooks provided just above the hold-down bolts.

c. Remove the oil cloth and unpack all unattached parts stored around the cradle in the base of the shipping box.

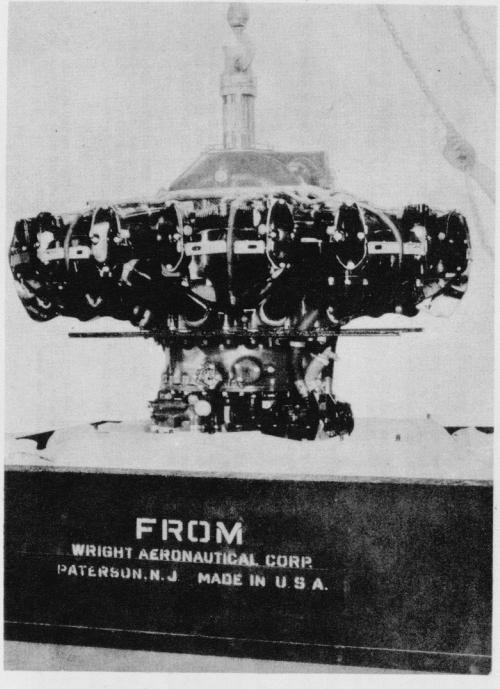

FIG. 8 - REMOVING ENGINE FROM SHIPPING BOX

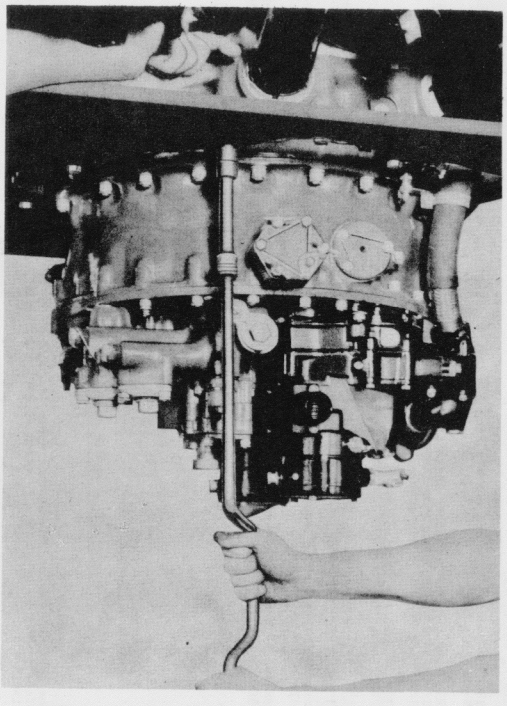

FIG. 9 - REMOVING ENGINE MOUNT PLATE

d. Prepare the engine for service in accordance with instructions issued in T. O. No. 02-1-1 with the following additions:

(1) Remove the nuts and washers from the ten bolts holding the steel mounting plate to the cradle of the shipping box.

(2) Install the propeller shaft lifting eye to the end of the propeller shaft and using a hoist of at least 1 ton capacity, raise the engine with the steel mounting plate from the box to a height at which the rear end is accessible.

(3) Remove the steel mounting plate by loosening the eight attaching bolts through the mounting lug section of the engine.

(4) Figure 8 shows the procedure for removing the engine from the shipping box (the same method may be used for installing). Figure 9 shows details of removing the engine mount plate.

e. Prepare the carburetor for service in accordance with instructions issued in T. O. No. 02-1-1 with the following addition:

Remove all drain plugs and drain off any oil not removed at the time of preparation for shipment or storage. Replace the plugs and lockwire. The carburetor will then be ready for installation.

SECTION V

INSTALLATION IN THE AIRPLANE AND REMOVAL THEREFROM

1. General

a. The instructions in this section apply in general to the installation and removal of these engines. Refer to Section II of this Technical Order, and to the Handbook of Instructions covering the particular airplane in which installed for specific installation instructions.

b. Complete instructions relative to the removal of an engine from the shipping box and preparation of the engine for installation are given in Section IV of this Handbook.

2. Hoisting Engines with Engine Hoist

a. Improper use of the engine hoisting equipment may result in serious damage to the engine.

b. The hoisting equipment supplied with the engine must not be used for the purpose of lifting an airplane or for lifting an engine which is attached to its mount. The equipment must not be attached to any part of the engine except where it was designed to be attached.

c. The hoist sling is attached to the cowl attaching studs of the intake rocker boxes of cylinder Nos. 1 and 9. Secure the legs of the sling to both the front and rear of the rocker boxes with lockwashers and nuts.

d. Refer to Figure 10 for a view of the engine lifting sling in position.

e. Raise the engine to the level flight position with a chain hoist of suitable capacity. The airplane should be in the level flight position.

3. Mounting the Engine

a. There are two methods of mounting the engine in the airplane, depending on the type of engine mount that is used. If the mount is the detachable type, it is believed that it will be found most convenient to install the engine, with the mount attached, as a unit. However, it may be desirable (and, if a fixed type mount, necessary) to install the engine on the mount with the mount installed on the fuselage. The type of mount and the amount of space between the fire wall and the mounting ring are, generally speaking, the determining factors in the method to be used.

b. If the engine mount is not to be detached, remove the carburetor and adapter from the engine according to paragraph 9 of Section VIII. It will probably be necessary to remove all accessories mounted on the side drives so that the rear crankcase sections will clear the mounting ring. Refer to Section VIII for instructions covering removal of accessories. After removing an accessory, cover the openings with a cover plate.

c. A great deal of trouble can usually be avoided, particularly if the installation is "Tight", by attaching at this time the accessories that are to be mounted on the rear of the engine. At any rate it is advisable to install the heavier ones such as starters and generators.

FIG. 10 - ENGINE HOISTING SLINGS

d. Raise the engine to the level of the mounting ring. It will be found that the engine hangs so that the plane of the mounting boss faces of the engine is approximately parallel to the plane of the mounting lug faces of the mounting ring. Attach the engine to the mounting ring. Inspect the shock absorbing equipment for proper operation. Be sure that the mounting bolt nuts are tight and properly locked.

e. Attach the various accesscories, fuel and oil lines, instrument lines, carburetor and scoop, oil radiator, control rods and cables, and ignition wiring in the order that the space renders most convenient. It will usually be found convenient to attach the exhaust system last. Make sure that all nuts are tight and properly safetied. See that all parts are properly braced to prevent vibration and chaffing. Inspect all controls to see that they operate throughout their full range without restriction. Refer to the following paragraphs in this section, Section IX, and the installation drawing, and make sure that all connections and accessory installations are in accordance with the instructions given.

f. Install the cowling and propeller. For complete instructions on the installation of propellers refer to the Handbook of Instructions for the particular propeller installed.

g. If it is desired to assemble the engine and its mount as a unit, the same general procedure is followed as is outlined above, the principle difference being that the engine mount and the various accessories are installed on the engine while the engine is still suspended from the chain hoist.

h. If this method is used it will be necessary to support the engine with additional cables due to the added weight and to provide the proper balance. If a metal cable is looped around the mount structure or the propeller shaft, it should be properly padded to prevent marring. Make sure that the engine mount is securely bolted to the fuselage.

i. Refer to T. O. No. 02-1-1 for instructions on servicing the engine prior to starting.

4. Supercharger Drain Valve

A standard fitting and suitable drain line should be attached to the supercharger drain valve, at the bottom of the supercharger rear housing. This line should be led outboard and the opening should face the slip stream.

5. Oil Connections

A boss for mounting a hydro-control oil pressure indicator is provided at the crankcase front section. (Refer to Section II.) Also refer to Section II for a description of the oil-in thermometer and oil pressure connections.

6. Fuel System

a. The priming connections at the engine are located at the intake ports of the cylinders. Make sure that the primer distributor inlet connection is securely clamped to No. 1 intake pipe, that all connections are tight, and that the lines are properly braced. Connect the discharge line from the pump to the distributor inlet.

b. Refer to Section II for a description of the fuel system connections.

7. Tests

Complete instructions for "Block, Installation and Flight Tests" are contained in T. O. No. 02-1-4.

8. Removing the Engine

a. These instructions are applicable only for a typical installation and where they conflict with specific instructions contained in the airplane Handbook, the instructions in the airplane Handbook should be followed.

b. Remove propeller, following the instructions in the applicable propeller Handbook. Place a cap over the front end of the propeller shaft.

c. Remove the cowling and attach the cable hoist sling as described in paragraph 3 of this section. Pad the detachable mount structure and loop additional cables around it to the hook of the hoist to which the rocker bolt cable sling is attached. Disconnect all controls, lines, and mount attaching bolts at the firewall and swing the engine with its mount assembly clear of the airplane.

d. Lower the engine and attach to a portable stand if available, otherwise leave it in the horizontal flight position at a convenient height for accessibility. Remove the air scoop, carburetor, and adapter and cover the opening to the induction chamber with wood or metal plate. Remove the exhaust manifold, gun synchronizers, fuel pump, tachometer, remaining cowling and whatever accessories impede removal of the mount structure, in the order that the space renders most convenient. (Refer to Section VIII of this Handbook for instructions on removal of accessories.)

e. Attach another hoist, if necessary, to the mount structure and remove the bolts attaching the front end of the mount to the mount blocks on the engine. Remove the mount structure from the engine.

f. Remove the remaining accessories from the engine and prepare the engine for storage in accordance with instructions in paragraph 2 of Section IV, unless it is to be disassembled or operated within 48 hours.

SECTION VI

ENGINE TROUBLES AND SERVICE REPAIRS

1. General

a. Determining the causes of engine troubles is at times rather involved due to the number of sources to which a given symptom may be attributed. The best method of "Trouble Shooting" is to first decide on the possible causes and then eliminate them one by one, starting with the most probable.

b. This table of the commonest troubles and their causes is submitted with the object of reducing wasted time and increasing the reliability of the engine.

2. Failure of Engine to Start

a. If the engine fails to start, it may be due to any one of the following conditions:

(1) Lack of fuel.

(2) Under-priming or over-priming. Refer to T. O. No. 02-1-29.

(3) Booster magneto defective.

(4) Throttle opening incorrect. Refer to T. O. No. 02-35GC-1.

(5) Mixture control. Make sure the mixture control is operated as instructed in T. O. No. 02-35GC-1.

(6) Defective ignition wire. Examine ignition wiring for wear, breaks, and incorrect connections.

(7) Dirty spark plugs. Check the spark plugs for proper functioning. Refer to T. O. No. 03-5E-1.

(8) Incorrect valve tappet clearance. Check the valve tappet clearance.

(9) Incorrect timing. Check the valve and ignition timing. Refer to Section VIII of this Handbook.

(10) For carburetor "trouble shooting", refer to T. O. No. 03-10BA-2.

(11) Cold oil. With the ignition switches off and mixture control in "Full Lean" position, turn the engine over by hand. If it is very stiff, it will be necessary to drain and heat the oil before starting.

(12) Magneto breaker points. See that the magneto breaker points are clean and properly adjusted. Test the spark delivered by the magneto. Care should be exercised in opening the breaker points. Refer to T. O. No. 03-5DA-2, and Section VIII of this Handbook.

b. The oil sump drain plug is equipped with a permanent magnet on the threaded end which is used as a means of trapping foreign particles in the oil sump. If some internal trouble is suspected this drain plug should be removed and any trapped particles examined.

3. Low Oil Pressure

a. Low oil pressure or none at all may result from one or more of the following:

(1) Lack of priming. Disconnect the oil suction line and fill the pump with oil. Turn the engine over by hand until the oil is sucked into the pump. Check the oil supply.

(2) Leak in suction lines. Examine the oil suction lines for air leaks.

(3) Dirt in oil filter. Inspect Cuno automatic filter for proper operation. Remove and clean if clogged.

(4) Air lock or dirt on the seat of the relief valve. Removing and replacing relief valve will often free the oil for circulation.

(5) Improper setting of relief valve. Adjust the oil pressure relief valve to obtain the value given in Section III of T. O. No. 02-35GC-1. If this pressure is not reached until the screw is all the way, or nearly all the way down, the trouble lies somewhere else. Adjustment of the pressure may be made with the engine running and should be made when the oil is hot.

(6) Excessive bearing clearance. A bearing may be worn enough to reduce the pressure, in which case an overhaul will be necessary.

(7) High oil temperature. Excessive temperatures reduce the viscosity of the oil, which then passes the bearings more freely and tends to drop the oil pressure. Check the oil cooler shutters for opening and check the cooler for clogging.

(8) Low outside temperature. In very cold weather the oil may become congealed in the suction line from the oil tank, preventing the oil from reaching the pump.

(9) Foaming in oil supply tank. Foaming is a frequent cause of fluctuating oil pressure and loss of pressure. The presence of air in the scavenge oil is normal. The return of oil from the engine should be directed into the supply tank in such a manner as to produce a minimum of splashing, and to permit air which may be trapped in the return line to separate from the oil as readily as possible. If foaming is experienced the oil should be removed from the system and the oil system cleaned. Refer to paragraph 5.of this section for other causes of oil foaming.

(10) It should be remembered that the pressure will vary with the varying engine speeds and oil temperature, and due allowance should be made for the pressure drop to be expected at increased temperatures.

4. Oil Accumulation in Crankcase

a. The filling of the crankcase with oil is usually caused by lack of priming in the scavengeing pump. Disconnect the main discharge line from the engine and put on a short length of hose. While turning the engine backward, feed oil into the hose until a quart or so has been sucked in. Check the oil pump, strainers, and lines for failures or stoppages.

b. Oil accumulation in the engine crankcase may also be due to high inlet temperature or pressure. Suggestions for determining the cause of excessive inlet temperature are listed in paragraph 6. of this section. If high pressure appears to be the cause the oil pressure relief valve should be checked and corrected.

5. Oil Foaming

In addition to the causes of oil foaming given above, experience indicates that foaming and serious attendant difficulties may result from the cleaning of engine parts with water mixed cleaning solution, most of which contain either soap compounds or caustic soda. Instructions on cleaning parts are given in T. O. Nos. 01-1-1 and 02-35GC-3.

6. Excessive Oil Temperature-High Oil Consumption

a. This condition may result from:

(1) Insufficient oil cooling.

(2) Insufficient oil supply.

(3) Low grade oil.

(4) Suction pump failing to scavenge the oil properly from the crankcase.

(5) An overheated bearing.

(6) Dirty oil.

(7) Worn piston rings.

(8) Piston rings incorrectly installed.

(9) Improper venting of oil system.

(10) Clogged oil lines, strainers, or coolers.

7. Low Power and Uneven Running

a. Low power and uneven running may be traced to any of the following causes:

(1) Rich or lean mixture. Too rich a mixture is evidenced by uneven running, "torching", and black smoke from the exhaust. Too lean a mixture is evidenced by uneven running, overheating and backfiring. Adjust the mixture strength to the specified fuel air ratio.

(2) Leaks in induction system. Examine the intake pipes for cracks and for leaks at the cylinder and crankcase connections. Examine the carburetor and adapter flanges for tightness.

(3) Spark plugs. See that all the spark plugs are clean, that they have the proper clearance and that they are not burned. Test them for proper sparking. Be sure that the spark plugs are in good condition and of the recommended type. Refer to T. O. No. 03-5E-1.

(4) Valve and valve-gear trouble. Check the valve-tappet clearance, springs, washers, rocker arms, and push rods. Make sure the valves are not sticking. Refer to Section VIII of this Handbook.

(5) Poor fuel. Use only the recommended grade of gasoline and see that the carburetor has an ample supply at the specified pressure.

(6) Magnetos. See that the magneto breaker points are clean and properly adjusted. Check the operation of the magnetos. Refer to T. O. No. 03-5DA-2 and Section VIII of this Handbook.

(7) Ignition wiring deteriorated or burned. Check condition of terminals and check each wire with buzzer or light to locate any broken or grounded wires.

(8) Engine overheating. This condition may be caused by the conditions referred to in paragraphs (1), (2), (3), and (5) above. Continued running of an engine with cylinder temperatures beyond those specified in Section III of T. O. No. 02-35GC-1 is liable to cause considerable damage, so investigation of the cause should be started immediately. Other causes include improper cowling, high carburetor air temperature, thin oil, and insufficient oil cooling.

(9) Ice on carburetor air intake screen. Proper use of the carburetor air heater will result in smooth operation of the engine. Refer to Section II of T. O. No. 02-35GC-1.

8. Spark Plugs

a. When a spark plug is removed from the engine due to suspected trouble it should be inspected thoroughly before disassembly. Fairly accurate indications of engine conditions may be diagnosed by examination of the spark plug.

(1) If the electrodes are heavily coated with carbon, the compression of the cylinder should be checked to determine whether the piston rings are stuck or worn and allow oil to pass. Check the log book for evidence of high oil consumption.

(2) If the electrodes are clean but discolored and appear to have been running hot this may be due to the following:

(a) Detonation from poor fuel

(b) Operating at excessive manifold pressure

(c) Loose core

Check for proper grade of fuel. Check manifold pressure gage for proper functioning. Check the spark plug core for tightness.

(3) If the electrodes are coated with a white powder after operating with tetra-ethyl lead fuel, the plug may not have been firing but still subjected to excessive heat.

(4) A coating of fresh oil indicates that the plug is not firing.

(5) For items (3) and (4) above, check the ignition wires and spark plug terminals for failure. Check the magneto breaker point functioning and spark plug gap.

b. After the spark plug is disassembled the core should be inspected for defects in the mica insulation. If the mica insulation is broken, flaked, or dented, or if any of the mica laminations project beyond adjacent laminations the core should not be used.

c. T. O. No. 03-5E-1 gives complete information on the reconditioning of spark plugs, supplemented by paragraph 2, Section VIII of this Handbook.

9. Magnetos

Trouble with burned magneto breaker points may be traced in some instances to the application of excessive quantities of lubricant. If this is experienced the magneto breaker assembly should be thoroughly cleaned and readjusted in accordance with T. O. No. 03-5DA-2 and Section VIII of this Handbook.

10. Carburetor Leakage

a. Because of the fire hazard involved, the engine will not be run if the carburetor leaks fuel excessively. Leakage of the carburetor may be caused by:

(1) Mixture control in wrong position. Refer to T. O. No. 02-35GC-1 and T. O. No. 02-1-29 for proper use of the mixture control.

(2) Improper functioning of the discharge nozzle valve in the carburetor adapter.

CAUTION: In no case will the carburetor be disassembled to correct any leakage. Replace the carburetor instead.

(3) Refer to T. O. No. 03-10BA-2 for complete service instructions on the carburetor.

11. Leakage of Supercharger Drain Valve

a. Leakage of the supercharger drain valve is often caused by dirt or foreign matter which hinders the sliding action of the piston, or which prevents seating of the disc or ball check valves.

b. In some instances, valve faces may require lapping to effect the proper seal. The valve faces must not be lapped together.

c. Improper fit of the piston in the valve body might also cause leakage.

12. Cold Weather Precautions

a. With installations in which the oil dilution system is employed, the cold weather stopping and starting procedure is outlined in T. O. No. 02-1-29.

b. For other installations it is necessary to preheat the oil before starting in extremely cold weather. A great deal of time can be saved by draining the oil from the tanks as soon as operations for the day are concluded. If left in the tank over night, the oil may become so viscous as to require considerable time to drain.

c. In cold weather it is also advisable to have some sort of lagging on the external oil lines on the engine to and from the tank. This will result in higher oil temperature at cruising speed and will decrease the danger of stoppage due to congealed oil. A layer of asbestos cord, shellacked and then wrapped with friction tape provides very good insulation. Lacking asbestos, several layers of ordinary packing cord can be used.

d. A large size oil pressure gage line is essential in cold weather to obtain an immediate indication of any pressure variation in the engine. For complete information on cold weather operation of oil pressure gages, refer to T. O. No. 05-40-10.

SECTION VII

SERVICE INSPECTION AND MAINTENANCE

1. General

a. The work outlined in this section is a normal function of the operating organizations at Air Corps stations. It consists of the periodic inspection, cleaning, servicing, lubricating, adjusting and such maintenance work as the organization facilities will permit.

b. For Preflight inspection, refer to the Handbook for the airplane in which the engine is installed.

c. In accordance with T. O. No. 00-20A-2, a summary of the periodic inspection prescribed in this section will be entered on the master Airplane Maintenance Instruction Forms maintained in the back of AAF Form 41-B for the airplanes affected.

d. The necessary tools for this work may be found listed in the Service Tools Catalog, T. O. No. 02-35-2.

2. Inspection and Maintenance

a. Column No. 19 - Daily - Power Plant. - (1) Inspect for evidence of engine throwing oil.

(2) Inspect for proper safetying of all drain plugs, covers etc.

b. Column No. 22 - Ignition and Electrical. - (1) Inspect and maintain spark plugs in accordance with T. O. No. 03-5E-1 and magnetos in accordance with T. O. No. 03-5DA-2.

(2) 50-Hour: Inspect ignition shielding for proper anchorage and security of union nuts.

NOTE: Whenever it is necessary to resolder any part of the ignition manifold assembly, refer to T. O. No. 02-1-9.

c. Column No. 23 - Fuel System. - Inspect and maintain carburetor in accordance with T. O. No. 03-10EA-2.

d. Column No. 24 - Oil System. - (1) Oil screens will be removed and cleaned whenever oil is changed. (Refer to T. O. No. 06-10-1 for oil changing periods).

(2) Remove and clean the Cuno filter at each oil change and at the end of the first five (5) hours' flying following each oil change.

NOTE: Whenever oil screens and the Cuno filter are removed for cleaning the inside of the sediment chamber will also be cleaned thoroughly.

(3) 25-Hour: (a) Remove and clean the Cuno oil filter in accordance with instructions in T. O. No. 02-1-24.

(b) Inspect all oil lines for: leaks, particularly at connections; security of anchorage; wear, due to chafing or vibrations; dents or cracks.

(4) 50-Hour: (a) Remove and clean all removable oil screens, and the Cuno oil filter in accordance with instructions in T. O. No. 02-1-24.

(b) Inspect the magnetic sump plug for trapped particles.

(5) Engine Change: Clean oil screens and the Cuno filter on newly installed engines in accordance with T. O. No. 02-1-4.

e. Column No. 25 - Cooling System. - (1) 25-Hour. - Inspect cylinders for damaged or broken fins.

(2) 50-Hour: (a) See that deflectors are properly fastened and do not rub fins.

(b) Inspect the cylinder head rocker boxes for chafing caused by the cowl.

f. Column No. 26 - Valves

NOTE: When it is known in advance that an airplane engine will not be operated for a period of more than one week, or that the engine will be placed in extended storage, the engine will be treated as specified in T. O. No. 02-1-1 to prevent corrosion.

(1) Clearances between rocker arms and valve spring upper washers will be checked in accordance with instructions in T. O. No. 02-35-6.

(2) These engines are equipped with internal automatic lubrication of the valve mechanism. The valve mechanism of these engines will be inspected and adjusted in accordance with instructions and periods specified in T. O. No. 02-1-6.

(3) In accomplishing the work prescribed by T. O. No. 02-1-6, the following additional instructions will be complied with:

(a) Check for broken springs.

(b) Check condition of rocker box cover gaskets.

(4) Refer to Section VIII of this Handbook for instructions on adjustment of valve clearances.

g. Column No. 27 - Manifolds and Superchargers. - (1) Inspect and tighten intake pipe packing nuts in accordance with instructions in T. O. No. 02-1-28.

(2) 50-Hour: (a) Ascertain that push rod housing clamps and tappet guide nuts are tightened.

(b) Inspect intake system for security of attachment, leaking gaskets, broken studs and leaks in the pipes.

(c) Ascertain that carburetor heater and scoops are securely fastened.

h. Column No. 28 - Propellers and Accessories. - Inspect thrust bearing nut and tighten if necessary in accordance with instructions in T. O. No. 02-1-34.

i. Column No. 29 - Power Plant - General. - (1) Inspect cylinder stud nuts and tighten, if necessary, in accordance with instructions in T. O. No. 02-1-55.

(2) 50-Hour: (a) Inspect cylinders for general condition.

(b) Check the compression on each cylinder. This should be done before the engine has thoroughly cooled after running. The compression should be checked at the first 50-Hour inspection following engine installation and at each second 50-Hour inspection (100-Hour) thereafter.

(3) 100-Hour: (a) Check compression on each cylinder as noted above.

(b) Check tightness of rocker box cover stud nuts. Avoid excessive tightness.

(c) Inspect crankcase breather outlets for obstruction at first 200-Hour inspection after engine installation.

(4) Engine Change: (a) When an engine is changed, accomplish all special inspections and maintenance work prescribed by technical instructions to be done at engine change.

(b) Newly installed engines will be ground tested and flight tested in accordance with T. O. No. 02-1-4.

(c) Prepare replace engines for storage as specified in T. O. No. 02-1-1.

3. Additional Inspection and Maintenance Instructions Issued by the Air Corps

SECTION VIII

ADJUSTMENT, REPLACEMENT AND MINOR REPAIR

1. General

a. The work outlined in this section can be performed with the facilities usually available at Air Corps Stations.

b. The object of the instructions in this section is to establish the correct procedure for the replacement of such component parts of the engines as cylinders, carburetors, magnetos, starters, etc.

c. The overhaul instructions are outside the scope of this Handbook but will be found in T. O. No. 02-35GC-3 and applicable Technical Orders covering overhaul of accessories.

2. Spark Plugs

a. Complete information concerning the spark plugs of these engines may be found in T. O. No. 03-5E-1 and Section VI of this Handbook.

b. Supplementing paragraph 2.a. above, it should be noted that the thickness of the solid copper gaskets or washer type thermocouples used with these engines must conform to the following limits:

Maximum - .095", Minimum - .068". This is to obtain the maximum efficiency of the spark plugs, less danger of overheating and detonation, and ease of removal.

3. Cylinder Air Deflectors

a. To accomplish minor repair work on the cylinder assemblies it is frequently necessary to remove cylinder head or cylinder barrel air deflectors.

b. Removal of Cylinder Head Air Deflectors. - If not previously removed, remove the rear spark plug ignition lead from the channel in the deflector. Break the lockwire and remove the fillister head screw which secures the attaching flange at the cylinder intake port. Break the lockwire from the two fillister head screws at the top of the deflector and remove the screws. The cross member is slotted to permit easy access with a screw driver.

c. Installation of Cylinder Head Air Deflectors. - (1) Place the air deflector in its approximate position on the cylinder head. Loosely install the three fillister head screws. Insure that lockwashers are installed under each of the screws and tighten down each screw evenly. Lockwire each of the screws securely. If the cross members were disassembled, new elastic stop nuts should be used during assembly.

(2) Place the rubber covered ignition lead to the rear spark plug into its channel section in the deflector. Press the lead down into the channel so that it is below the contour of the cross members of the deflector.

d. Removal of Cylinder Barrel Air Deflectors. - (1) To remove the cylinder barrel air deflectors of any of the upper five cylinders, it will first be necessary to remove the priming system tubes (if used) in accordance with the instructions outlined in paragraph 4 of this section.

(2) Remove the intake pipes, using the procedure described in paragraph 5 of this section.

(3) Remove the elastic stop nut and washer from the through bolt securing the cylinder barrel deflector and the barrel clamp. Remove the elastic stop nut and washer from the stud holding the deflector at the rocker box cover extension locations. The rubber grommet and plate should be temporarily bolted to the deflector stud to prevent loss. Remove the cylinder barrel air deflector from the rear. It will be unnecessary to remove the rubber packing unless replacement is required.

(4) To remove the cylinder barrel air deflector from the sump section, remove the nut, retaining plate and grommet securing the deflector to the rocker box cover extensions. Break the lockwire and remove the two capscrews securing the deflector to each leg of the sump. Withdraw the deflector to the rear.

e. Installation of Cylinder Barrel Air Deflectors. - (1) Place the air deflector in its approximate position between the cylinders.

(2) Place the air deflector clamp so that the edges of the channel shaped clamp fit into the fifth and eleventh fin space, counting the space between the first and second fin at the crankcase end of the cylinder as No. 1. Loosely install the through bolt through the deflector, spacer and clamp. Install a new elastic stop nut but do not tighten at this time. Line up the deflector so that the stud protrudes through the space between the two rocker box cover extensions. Install the grommet and retaining plate, secure with a new elastic stop nut. Tighten the air deflector clamp at the base of the air deflector.

(3) To install the air deflector at the sump location, place the deflector in its approximate position. Loosely install the two capscrews and washers securing the deflector to the two legs of the sump. Line up the stud with the space between the two rocker box cover extensions, install the rubber grommet and retaining plate and secure the assembly with a new elastic stop nut. Tighten the capscrews in the sump legs and lockwire securely.

4. Priming System

a. Removal. - Detach the supply line from the distributor. Unscrew the priming tube union nuts from the fitting on the intake ports of the five upper cylinders and at the distributor nipples. If the same tubes are to be installed, tag, or otherwise mark each priming tube to indicate to which cylinder it is attached. Remove the nut, washer and bolts securing the priming tube clamps to the intake pipes. Spread open the clamps and remove the priming system tubes. It will be unecessary to remove the distributor from the No. 1 cylinder intake pipe if this unit does not require replacement. Exercise extreme care in removing the priming tubes to prevent their bending. A bent tube will present great difficulty in installation and may restrict the flow of the priming charge in the tube.

b. Installation. - (1) If removed, attach the distributor to the clamp and place the clamp on the No. 1 cylinder intake pipe facing the rear, and at its approximate mid position. Do not tighten the clamp at this time. Place each priming tube in its approximate location and slip the clamps over the intake pipes. Install the nuts and bolts but do not tighten. Screw on the union nuts at the intake ports and the distributor. Tighten each union nut at the intake port and distributor locations. Tighten all the clamp nuts.

(2) Refer to Figure 15 for a diagram of the priming system.

5. Intake Pipes

a. Removal. - (1) The intake pipes of the upper five cylinders support the priming system. When removing any of these intake pipes, it will first be necessary to remove the priming system tubes as described in paragraph 4 of this section.

(2) Loosen the packing nut at the crankcase end of the intake pipe. This may be done with the special crowfoot type wrench which fits the castellations on the nut snugly.

(3) Remove the three capscrews at the flanged end of the intake pipe. Remove the washers and pull the flange back from the intake port. Discard the gasket.

(4) Withdraw the intake pipe from the supercharger front housing. Remove the packing nut and packing. Discard the packing.

b. Installation. - (1) Install a new packing ring in the supercharger front housing port and loosely install the packing nut.

(2) Coat the crankcase end of the intake pipe with clean engine lubricating oil and insert into the supercharger front housing.

(3) Install a new gasket at the intake pipe attaching flange and the intake port parting surface and install the three capscrews making sure a shake-proof washer is installed under the head of each capscrew. Tighten each capscrew evenly, and lockwire securely. Tighten the packing nut at the crankcase end of the intake pipe using the crowfoot type wrench and handle.

6. Oil Sump

a. Removal. - (1) If not already removed, remove the No. 5 cylinder intake pipe as outlined in paragraph 5 of this section. It will also be necessary to remove the cylinder air deflectors as described in paragraph 3 of this section if they are not already removed.

(2) Break the lockwire, and remove the screened and magnetic drain plugs from the bottom of the sump. Drain the oil into a clean receptacle, strain and examine carefully for foreign material. Reinstall the plugs loosely in their proper locations to prevent their loss.

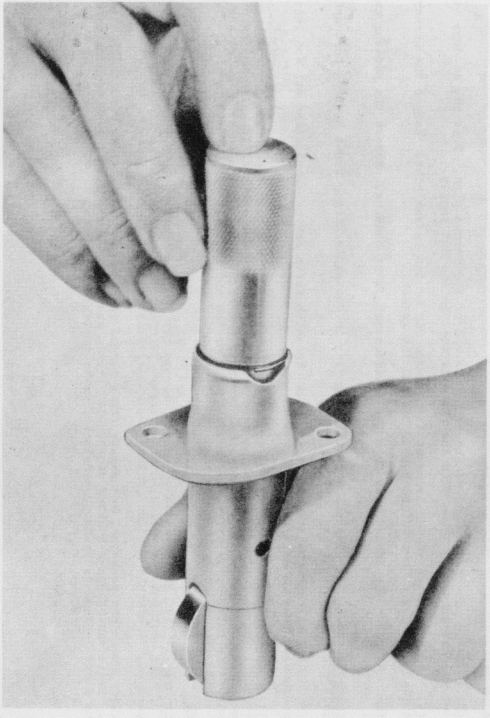

FIG. 11 - INSTALLING VALVE TAPPET IN GUIDE

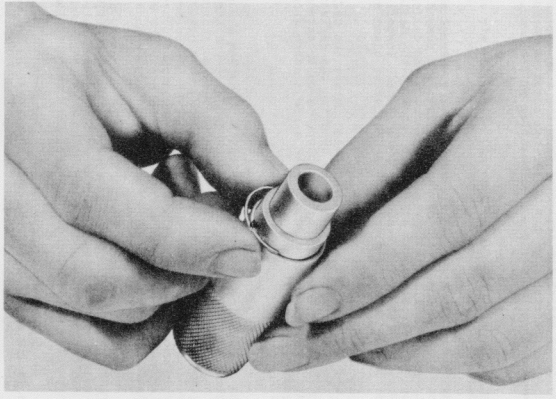

FIG. 12 - INSTALLING VALVE TAPPET RETAINING CIRCLET

(3) Remove the three palnuts, nuts and washers securing the front attaching flange to the crankcase front section.

(4) Support the sump and remove the two palnuts, nuts and washers from each arm of the sump which secures it to the supercharger front housing. Withdraw the sump.

b. Installation. - (1) Remove the screened and magnetic plugs from the bottom of the sump.

(2) Install new gaskets at the mounting flange locations. Make sure that the oil holes line up perfectly with the holes in the sump.

(3) Place the sump into its proper position and install the washers and nuts. Tighten all nuts evenly to the proper tightening torque as listed in T. O. No. 02-35-1. Install palnuts on each of the studs and tighten as directed in T. O. No. 02-1-10.

(4) Reinstall the screened and magnetic drain plugs using new gaskets under each. Lockwire the plugs securely together.

(5) Reinstall the air deflectors and intake pipes as directed in paragraphs 3 and 5 respectively of this section.

7. Push Rods and Valve Tappets

a. Removal and Disassembly. - (1) The following procedure is given for cases in which it is desired to remove a push rod without removing the rocker arm hub bolt or disturbing the torque setting which has previously been applied to the rocker bolt nut.

(a) Remove the clips securing the ignition leads of the manifold to the push rod housings. It will be unnecessary to remove the clips from the leads.

(b) Loosen the two hose connection clamps at the crankcase end of the push rod housing and the single hose clamp at the cylinder end of the housing. Slide the crankcase end hose connection along the push rod housing until the bead on the end of the housing is visible.

(c) Remove the nuts, lockwashers and plain washers from the four rocker box cover attaching studs of the rocker box from which the push rod is being removed and remove the cover. Loosen the adjusting screw lockscrew in the rocker arm and screw the adjusting screw all the way out to its stop. Screw the push rod removing tool on the extended threads of the valve clearance adjusting screw and insert the handle to serve as a lever and compress the valve spring. The push rod, housing and hose connection may be removed as a unit through the slot in the tappet guide.

(2) If the special push rod removing tool is not available, it will be necessary to remove the rocker arm before the push rod can be withdrawn. Remove the rocker box cover as previously described. Remove the cotterpin from the rocker bolt nut and remove the nut. Turn the crankshaft so that the valve is seated and a clearance exists between the rocker roller and the valve stem. Push or drive out the rocker bolt, being careful not to damage the bolt threads, and remove the spherical seat washer from each end. Lift out the push rod and remove the housing by loosening the clamps and sliding the crankcase end connections along the housings.

(3) Remove the loose fitting valve tappet ball socket and mating spring, turning the crankshaft, if necessary, to push the tappet in reach. Remove the palnuts, nuts and washers from the two tappet guide attaching studs and withdraw the tappet and guide assembly from the crankcase front section. If the guide cannot be removed by hand, attach the tappet guide puller. This consists of a rod which clamps to the bead on the tappet guide. A weight slides along the rod to provide the necessary inertia for removing the guide. Remove the gasket under the guide flange.

(4) The tappet and guide assembly may be separated by inserting the hooked end of the valve tappet circlet removing tool under the retaining circlet to effect its removal. Do not attempt to make the circlet jump out of its groove by striking the hollow end of the tappet with a drift. Care should be taken to avoid loss of any of the parts during this operation as the floating tappet roller, bushing, and pin are exposed when the retaining circlet is removed. The tappet may be separated from its guide and complete disassembly of the roller and bushing effected by pushing the floating pin out of the slotted end of the tappet.

b. Assembly and Installation. - (1) Place the tappet roller equipped with its floating bronze supporting bushing in the slotted end of the tappet and insert the floating pin. Slide the tappet and roller into the tappet guide and install the retaining circlet with the installing tool. Refer to Figure Nos. 11 and 12. Install a new gasket under the tappet guide flange and insert in the crankcase front section. Install a plain washer, nut and palnut on each of the two attaching studs. Insert the coiled spring and valve tappet ball socket into the hollow tappet. Insure that all parts are thoroughly coated with engine oil before assembly.

(2) Install a new short hose connection and one clamp on the rocker box end of the push rod housing. This end of the push rod housing may be identified by the location of the beading which is approximately 3/8" from the end. Install new long hose connection and two clamps on the crankcase end of the housing. The beading at this end of the housing is directly on the end. The installation of the hose connections will be facilitated if a thin coat of engine oil is placed on the housing.

(3) When assembling a push rod assembly, which was withdrawn without removing the rocker arm, proceed as follows:

(a) Oil the push rod ball end and insert the push rod in its housing having the hose connection at the crankcase end flush with the bead on the housing.

(b) Compress the valve spring and rocker arm, using the tool described in the removal instructions. With the valve spring compressed, slide the push rod housing hose connection into position at the rocker box and push the crankcase end of the push rod through the slot in the tappet guide.

(c) Remove the valve spring compressing tool from the rocker arm. Push the push rod housing all the way into its rocker box hose connection and tighten the hose clamp. Slide the crankcase end hose connections over the tappet guide and tighten both hose clamps.

(d) Set the valve clearance in accordance with the instructions in paragraph 8 of this section.

(4) If the rocker arm was removed when the push rod was removed, the following additional instructions are applicable:

(a) With the hose connections and clamps assembled on the push rod housing, install the housing on the engine pushing it all the way into its rocker arm hose connection while tightening the clamp. Slide the crankcase end hose connection over the tappet guide and tighten both clamps.

(b) Oil the push rod ball ends with clean engine lubricating oil and insert in the push rod housing through the rocker box. Install the rocker arm and insert the rocker bolt through its hub. Insure that the spherical seat washers are installed at each end of the through bolt. The bolt should be installed with the head facing the cylinder head centerline.

(c) Before tightening the castellated nut on the rocker bolt, check the end clearance between the bearing inner race and the rocker box. If it is over the limit specified in T. O. No. 02-35-1, remove the bolt and install a shim to take up the excess.

(d) Tighten the rocker bolt nut to the torque value specified in T. O. No. 02-35-1 using the torque indicating handle. If the hole in the bolt cannot be lined up when using the correct torque value, remove the nut and install a new washer. Repeat the above procedure. Install a new cotterpin of the correct size.

(e) Set the valve tappet clearance in accordance with the instructions outlined in paragraph 8 of this section.

(f) Fill the rocker boxes with clean engine lubricating oil and install a new gasket over the rocker box cover attaching studs. Install the cover and secure with plain washers, shake-proof washers and nuts.

(g) Reinstall the ignition harness retaining clips on the push rod housings, if removed.

8. Cylinders, Valves, Pistons

a. Cylinder Removal. - (1) Remove the four exhaust stack attaching nuts and lockwashers. It may be found necessary to remove whole or part of the exhaust manifold in order to facilitate the removal of the cylinders.

(2) Disconnect the ignition leads to the front and rear spark plug terminals and remove the air deflectors in accordance with the instructions given in paragraph 3 of this section.

(3) Remove the intake pipe following the instructions in paragraph 5 of this section. It may be necessary to remove the intake pipe of the adjacent cylinder for accessibility.

(4) Remove the rocker box covers, rocker arms, push rods and housings according to paragraph 7 of this section.

(5) To remove cylinders adjacent to the two main front to rear ignition shielding conduits it will be necessary to remove all the attaching clamps, and the knurled nuts on the shield assembly. Otherwise the cylinder hold-down capscrews will not be accessible.

(6) To remove the cylinders adjacent to the oil sump, the oil sump must first be removed following the instructions outlined in paragraph 6 of this section.

(7) Remove the spark plugs using the wrench specified in T. O. No. 03-5E-1.

(8) Turn the crankshaft until the piston of the cylinder being removed is at the top of its stroke. Break the safety-wire from the cylinder hold-down capscrews and remove the capscrews. Remove the spherical seat washers from the cylinder flange, and pull the cylinder out straight clear of the piston.

FIG. 13 - REMOVING PISTON PIN RETAINER

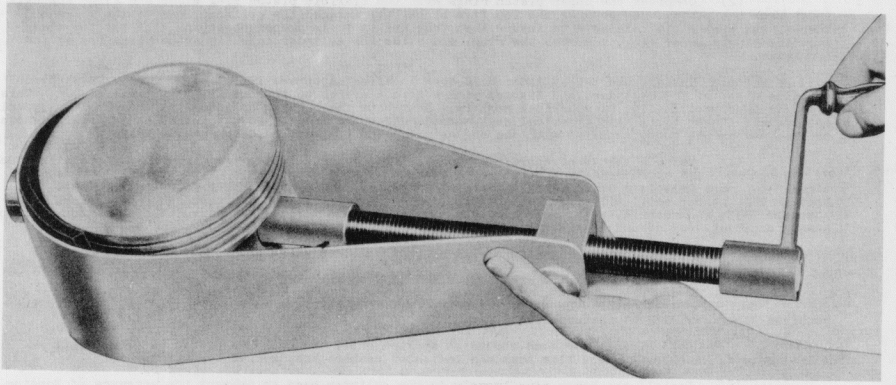

FIG. 14 - REMOVING PISTON PIN

(9) As the cylinder is being removed from the engine, but before the cylinder skirt clears the bottom piston ring, a cloth should be drawn around the connecting rod and spread over the cylinder hole to prevent pieces of broken piston ring from falling into the crankcase.

(10) Install a connecting rod guide on the cylinder pad, and secure it temporarily with two capscrews. Install a fin protector around the cylinder if the cylinder is to be used again.

b. Piston Removal. - (1) Remove both piston pin retainers using the tool indicated in T. O. No. 02-35-2. Insert the spade-shaped end of the tool between two of the coils of the spring and turn the handle 90°. Pry out the spring, resting the leg of the tool against the wall of the piston. Place one hand over the piston pin bore to catch the retainer as it is pried out. Figure 13 shows the application of the retainer removing tool.

(2) Push the piston pin out of the piston with the fingers. If the pin is tight or stuck, it may be removed with the tool listed in T. O. No. 02-35-2. Encircle the piston with the felt lined stirrup of the tool and turn down the spindle which forces out the piston pin. Cover the cylinder pad on the crankcase to prevent the entrance of any foreign material. Figure 14 shows application of piston pin removing tool.

c. Piston Installation. - (1) Install a new piston pin retainer in the rear piston pin retainer groove of each piston in the following manner. Place the retainer in the installing tool with the spring joint approximately 90° either side of the cut-out in the tool. Install the piston pin in the piston with the large diameter of the chamfer flush with the inner edge of the retainer groove. Insert the end of the installing tool in the piston pin from the side of the piston in which the retainer is to be installed with the cut-out portion of the tool at the top of the piston pin hole. While performing this operation, locate the top section of the retainer spring in the top section of the groove. Install the adapter in the opposite end of the piston pin and while holding the pin in position with one hand, apply pressure on the installing tool with the other and force the spring into its seat in the retainer groove. Remove the installing tool and piston pin.

(2) Turn the crankshaft so that the connecting rod is at the top of its stroke. Oil the piston pin, connecting rod, piston pin bushing and piston pin bore with clean engine lubricating oil. Install the piston so that the part numbers stamped on the dome of the piston face the rear. Insert the piston pin so that it bottoms against the retainer spring previously installed. Install the remaining retainer in the same manner as the first using the installing tools.

d. Cylinder Installation. - (1) Coat the cylinder barrel bore with clean engine oil and install a new oil seal ring below the hold-down flange. Thoroughly coat the piston and rings with clean engine oil, however, do not use excessive oil as drainage into the combustion chamber may cause fouling of the spark plugs. Set the piston rings so that the gaps are equally spaced (staggered) around the piston. Remove the connecting rod guide from the cylinder pad. Make sure that the cylinder pad is clean and dry.

(2) Compress the upper piston rings with the flexible piston ring clamp and slide the cylinder over the piston. As soon as the top five rings have entered the cylinder, remove the clamp and inspect the piston pin retainers to insure that they are in their proper position. Install the clamp over the single lower ring, compress the ring, and slide the cylinder into its proper location on the crankcase.

(3) Install the two cylinder hold-down locating capscrews (Refer to T. O. No. 02-35-3) on opposite sides of the cylinder, and tighten with a torque wrench to approximately 300 inch pounds. This prevents incorrect seating of spherical washers. Lubricate the regular hold-down capscrews with Glyptal and install finger tight with spherical seat washers under the heads. Do not install any clips, washers, or brackets except those supplied with the engine under the cylinder hold-down capscrews.

(4) Using a torque of approximately 300 inch pounds, tighten two capscrews on opposite sides of the cylinder and approximately 90° from each of the locating capscrews. Using the same torque, tighten two more capscrews on opposite sides of the cylinder and approximately 45° from the last. Proceed in this manner until all capscrews are tightened. Remove the locating capscrews and replace with standard bolts and washers, using approximately 300 inch pounds torque. Finally, tighten all of the capscrews consecutively around the cylinder, using the torque specified in the T. O. No. 02-35-1.

(5) The following precautions will be observed when using a torque wrench:

(a) Make sure the wrench does not bind on any part of the engine.

(b) Install the wrench in such a position that the capscrew may be pulled up to the required tightness without interruption.

(c) The torque load should be applied until the bolt has ceased to turn. This requires several seconds from the time that the indicator reaches the desired torque value.

(6) Install the spark plug loosely in the cylinder head to prevent the entrance of foreign material.

(7) Safety-wire the cylinder hold-down capscrews using a length of wire for each group of five capscrews. Twist the wire one turn between capscrews and together securely at the ends.

(8) Install the cylinder barrel air deflectors in accordance with the procedure outlined in paragraph 3 of this section.

(9) For cylinders Nos. 5 and 6 it will now be necessary to install the sump according to the instructions set forth in paragraph 6 of this section.

(10) Install the intake pipe on the cylinder being installed, as well as the adjacent intake pipe which was removed for accessibility. Instructions for this procedure are found in paragraph 5 of this section.

(11) Install the push rod housings, push rods and rocker arms according to the procedure outlined in paragraph 7 of this section. If interference exists between the rocker arm and standard valve spring washer it will be necessary to replace the valve spring upper washer with one having an undersize bore. This requires removal of the cylinder to a valve assembly block as previously described in this section. Refer to T. O. No. 02-35-6.

(12) After installation of any cylinder above the horizontal centerline, fill the rocker boxes with engine oil to assure ample lubrication when the engine is started the first time. Install the rocker box covers with gaskets using a plain washer, a shake-proof washer, and a nut on each of the attaching studs. Install the ignition wire attaching clips on the proper push rod housings and rocker boxes.

(13) Tighten the spark plugs into the cylinder head with the wrench designated in T. O. No. 03-5E-1, having copper gaskets or thermocouples under the shell of each which conform to the thickness specified in paragraph 2 of this section.

(14) On cylinders which were installed adjacent to the two main radio shielded ignition conduits, it will be necessary to attach the retaining yokes and tighten the couplings of the radio shielding.

(15) Install the cylinder head air deflector unit according to the instructions given in paragraph 3 of this section, and connect the spark plug ignition terminals.

(16) Install new exhaust flange gaskets under the exhaust stacks which were removed and reassemble the portion of the exhaust manifold which was removed or swung out of the way for the cylinder removal. Tighten all joints.

e. Adjustment of Valve Clearances. - Set the valve tappet clearance in accordance with the following instructions:

(1) Install the top center indicator in the front spark plug bushing of the cylinder in which the valve tappet clearance is being adjusted.

(2) Turn the crankshaft until the piston, in the cylinder on which the adjustment is being made, is at the top dead center position on the firing stroke (both valves closed) as shown on the indicator.

(3) Loosen the adjusting screw lockscrew. Screw in the adjusting screw until the rocker arm roller bears against the valve stem and the tappet spring is fully compressed. Tap the adjusting screw end of the rocker arm to insure that the spring is fully compressed.

CAUTION: When tightening valve adjusting screws observe additional instructions contained in T. O. No. 02-35-6.

(4) Turn the adjusting screw in a counterclockwise direction until the desired clearance of .010 inch is obtained as indicated by a strip of feeler stock. Tighten the adjusting screw lockscrew and check the adjusting screw for tightness. Recheck the clearance.

NOTE: Valve adjusting screws used on these engines have three (3) oil pressure holes incorporated. The screw is marked on the top surface with three (3) 1/16" diameter circles in line with the three (3) drilled oil passages. If one of these holes is aligned with the clamp joint of the rocker arm, oil will escape into the rocker box without properly lubricating the rocker arm bearing. Care will be exercised when adjusting the valve clearance in order to insure that none of the drilled holes in the adjusting screw line up with the clamp joint in the rocker arm within 3/32" If, after adjusting the valves to the desired value, the oil pressure hole is found to be closer than 3/32" to the nearest edge of the clamp joint turn the adjusting screw in the shortest direction that will bring the mark within the required limits and tighten the locking screw. However, if the oil pressure hole is in line with the clamp joint the valve clearance will be increased rather than decreased. The maximum error in the desired valve clearance caused by the above procedure is approximately .002", which will in no way effect engine operation.

(5) Adjust any remaining valve tappet clearances in accordance with the foregoing instructions.

9. Bendix-Stromberg Injection Carburetors

a. General. - For maintenance and servicing of the Bendix-Stromberg Injection carburetors with which these engines are equipped, refer to T. O. No. 03-10BA-2.

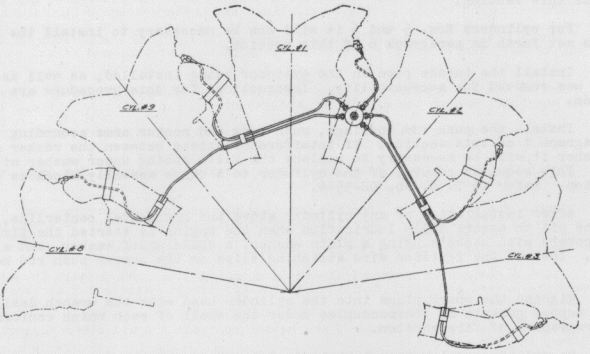

FIG. 15 - PRIMING SYSTEM

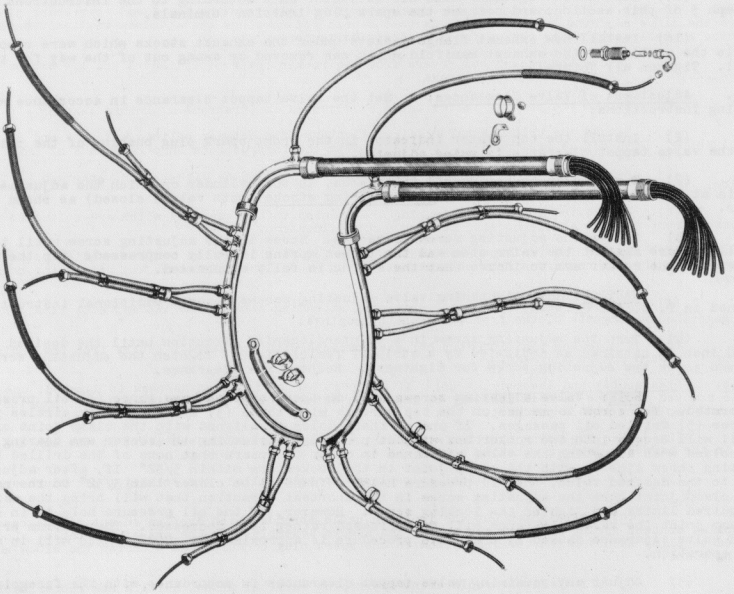

FIG. 16 - IGNITION MANIFOLD

b. Removal. - (1) Disconnect the throttle and mixture controls and remove all lines to connections in the carburetor and adapter. Remove all lines and heater controls from the air scoop.

(2) Remove the palnuts, nuts, and plain washers securing the air scoop to the carburetor and remove the air scoop. Remove the air screen to scoop gasket, screen, and screen to carburetor gasket.

(3) Remove the cotterpins, nuts, and spherical seat washers securing the carburetor to the supercharger rear housing. Remove the carburetor and gasket.

(4) Cover the opening into the induction chamber with a suitable cover or plate to prevent the entrance of foreign material into the induction chamber.

c. Installation. - (1) Before installing the carburetor, prepare it for service in accordance with the instructions given in Section IV, paragraph 5 e.

(2) Remove the cover plate from the mounting pad on the supercharger rear housing. Install a new gasket over the mounting studs. Place the carburetor in position over the mounting studs and install the spherical seat washers. Install the nuts, drawing them up snugly against the washers. Tighten all the nuts evenly, lining up the cotterpin holes and cotterpin securely.

(3) Place a new gasket over the air scoop mounting studs and install the screen. Install a new gasket between the screen and scoop, and install the air scoop. Secure the air scoop with plain washers, nuts, and palnuts.

(4) Connect the throttle mixture, and heater controls and all other connections to the carburetor, adapter, and air scoop.

(5) Check all controls for ease of operation and full travel.

10. Ignition Wire Harness

a. Removal. - (1) Disconnect the spark plug terminals from the front and rear spark plugs. Remove the clips securing the harness leads to the push rod housings and withdraw the ignition leads from the channel sections in the cylinder head air deflector.

(2) Remove the rocker box covers from the rocker boxes of cylinders No. 1 - exhaust, No. 1 - intake, No. 2 - exhaust, and No. 9 - intake.

(3) Remove the priming system tubes as directed in paragraph 4 of this section.

(4) Remove the cylinder barrel air deflectors from between cylinders Nos. 1 and 2, and Nos. 1 and 9. This may be performed in accordance with the instructions in paragraph 3 of this section.

(5) Remove the intake pipes of cylinders Nos. 1 and 9 as directed in paragraph 5 of this section.

(6) Remove the four clips securing the harness to the supports which are bolted to the crankcase front section at the housing parting surface location.

(7) Remove the two capscrews securing the top section of the radio shielding to each magneto. Remove the six capscrews from each magneto which secure the coil cover and retain the magneto blocks.

(8) Pull the section of radio shielding extending between the two magnetos straight up and disengage the two magneto blocks from the magneto housings.

(9) Remove the ignition wire harness complete with the magneto blocks from the engine, pulling it upward and to the rear.

b. Disassembly and Assembly. - (1) If any part of the ignition harness is damaged, the part may be removed from the harness assembly by loosening either one or more of its adjacent knurled couplings and replacing with a new part.

(2) When replacing ignition wire, dust each wire with talc and start it through the aperture in the harness, using a rotating motion and exerting a very slight pull.

(3) If a spark plug terminal is replaced or reinstalled, the following procedure should be used:

(a) Straighten out the ignition cable strands which are fanned out at the base of the coiled contact spring and pull the spring and sleeve assembly from the end of the cable. Loosen the knurled coupling securing the terminal elbow to the spark plug conduit, and withdraw the elbow and rubber packing gland.

(b) Install the replacement spark plug terminal elbow, using a new rubber packing gland.

(c) Make sure the contact spring and washer assembly are not loose in the terminal sleeve of the replacement terminal. This may be checked by inserting a 1/4" diameter rod in the sleeve bottoming on the contact washer. Place the other end of the rod on a scale and hold the sleeve with the fingers. Press down on the sleeve with a 12 to 13 pound load and observe the washer and sleeve for movement. Repeat the procedure with the sleeve inverted on the rod. If the contact washer moves in either direction, the sleeve assembly should be replaced. Refer to Figure 17.

(d) Twist the ends of the ignition cable slightly and insert the cable in the contact sleeve. The stripped end of the cable should protrude through the hole in the washer at the base of the contact spring about 1/8". Fan the strands of cable around the washer and press the strands securely into position over the end of the contact washer nipple by means of a short copper tube (1/8" I.D.).

(e) Insure that the terminal sleeve fits snugly into the recess in the terminal elbow and tighten the knurled coupling nut securing the terminal assembly to the radio shielding.

(4) To separate the magneto block from the ignition cables, observe the following:

(a) Remove the two slotted capscrews from each side of the magneto block housing and the two nuts and bolts at the top of the housing. The housing may be separated and removed from the magneto block.

(b) Remove the cable piercing screws adjacent to the electrodes in the distributor block and withdraw the ignition cables. Remove the booster cable if provided, by removing its piercing screw.

(c) The block may now be separated from the ignition cable assembly.

(5) To assemble the magneto distributor block to the ignition cables, proceed as follows:

(a) Insert the cables through the radio shielding if the shielding was removed. Insert the cables through the ignition wiring harness attaching flange at the top of the magneto, if removed.

(b) Apply powdered talc to the cables before inserting in the distributor block holes.

(c) A copper ferrule is swedged over the end of the ignition cable which is inserted in the magneto block. The cable strands are folded back under the ferrule to insure good contact and each ferrule is stamped with its distributor block number. Insert each ignition cable in its corresponding hole in the distributor block as denoted by the numbers on the ferrule and the magneto block. The numbers on the magneto denote the serial firing order of the magneto and not the cylinder numbers. Make sure that the cables bottom in the holes in the distributor block and screw down each cable piercing screw to insure security and proper contact. No lockwashers are employed under the cable piercing screws.

(d) If a booster magneto cable is employed, insert its end in the distributor block cable hole marked "B" and secure it with the cable piercing screw.

(e) If no booster wire is used, insure that a lockwasher is installed under the head of the cable piercing screw.

(f) Install the two halves of the distributor housing and secure with the slot-head screws and the nuts and bolts at the top of the housing. Tighten all the remaining screws retaining the housing assembly.

(6) Before installing the ignition shielding assembly, check the ignition wiring for shorts or open circuits and to ascertain whether the ignition cables lead to the proper cylinder from the magnetos.

(a) To test for a short circuit due to faulty insulation of the cable, a booster magneto should be used. Connect the high tension terminal of the booster magneto to a distributor block electrode and hold the spark plug end of the corresponding ignition cable about 3/8 inch from a suitable ground. If a good spark does not jump the gap, examine the cable for faulty insulation.

(b) To test for an open circuit in a cable and to check the firing order of the cylinders, a buzzer or light system should be used. Touch the distributor block electrode with one contact and the spark plug end of the cable with the other contact. The circuit is complete if the buzzer signals or the lamp lights. If the circuit is not complete, check for possible open circuit or wrong connection of the cables.

(c) The following table gives the relation between the cylinder and magneto firing orders:

Magneto Distributor Block Number	Cylinder Number
1	1
2	2
3	5
4	7
5	9

(d) Tighten all the knurled shielding coupling nuts and capscrews.

(7) Installation: (a) Place the ignition harness in its approximate position in the engine. Insert the magneto distributor block in its recess in the magneto housing using extreme care not to damage the contact buttons.

(b) Place the magneto coil cover into its position on the magneto and secure both the magneto distributor block and the coil cover with the six slot-head capscrews using a new lockwasher under the head of each capscrew.

(c) Install the four clamps securing the two halves of the ignition harness to the four supports which are bolted to the crankcase front section.

(d) Attach the flexible radio shielded ignition leads to the push rod housings by means of the clamps and secure the ignition leads for the front and rear of each cylinder together by means of clamps to prevent vibration of the leads.

(e) Install the cylinder barrel air deflectors as outlined in paragraph 3 of this section.

(f) Install the priming system tubes and intake pipes as directed in paragraphs 4 and 5, respectively, of this section.

(g) Place the rear ignition leads in their respective locations in the channel sections of the cylinder head air deflectors and attach the terminals to the spark plugs. Attach the front spark plug terminals to their respective spark plugs.

c. Magneto Ground Terminal. - (1) Removal

(a) Loosen the knurled coupling joining the radio shielded ground wire to the "Y" junction.

(b) Loosen the knurled coupling joining the radio shielded ground wire which interconnects the two magneto ground junctions.

(c) Remove the bail wire from the castellations on the ground terminal retaining nut and withdraw the magneto ground terminal assembly complete.

(d) Pull the brass contact away from the rubber washer and insulating sleeve and melt the solder at the ends of the contact. Withdraw the wire from the contact and sleeve assembly.

(2) Installation: (a) Strip back the insulation from the ground wire for about 3/16" and twist the wire slightly. Install the insulating sleeve with the flange toward the end of the wire. Install the rubber washer and insert the wire through the brass contact button. Pull the insulating sleeve and rubber washer away from the contact and fan the wire out slightly. Solder the wire to the contact button and file the solder flush with the end of the contact.

(b) Insert the ground terminal into the sleeve in the magneto breaker housing and secure the assembly with the knurled nut. Lock the knurled nut with the spring wire lock ring.

(c) Tighten the knurled coupling nuts securing the radio shielding at both ends of the "Y" terminal or install the cap if the terminal is not used.

(d) Refer to Figure 16 for a diagram of the ignition manifold assembly.

11. Magnetos

a. Removal. - (1) Remove the magneto air blast tube, if used. Remove the coil cover and distributor block in accordance with instructions in paragraph 10 of this section.

(2) Remove the magneto ground terminal as directed in paragraph 10 of this section.

(3) The Scintilla SF-9L-4 magnetos have a detachable distributor block shrouded by a two-piece radio shield. Radio shields for right and left hand magnetos differ slightly. In view of the fact that all the high tension ignition wires are secured to the distributor blocks, the block and radio shield of a magneto being locked, are also used in a replacement magneto of the same type, unless the block requires repair. The magneto cover incloses the coil and supports the distributor block. The cover may also be used on a replacement magneto of the same type. For maintenance and servicing of Scintilla SF-9L-4 magnetos, refer to T. O. No. 03-5DA-2.

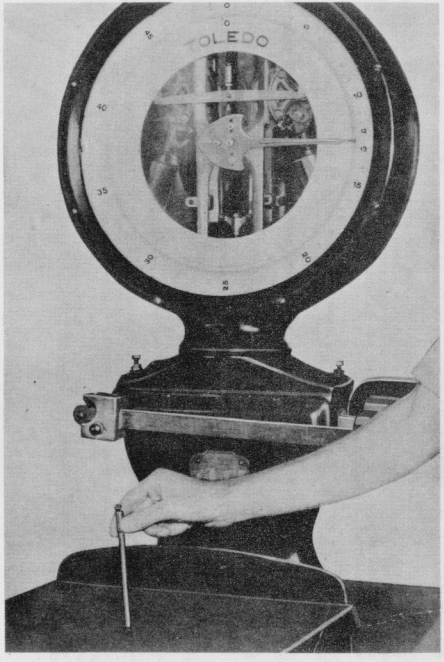

FIG. 17-CHECKING IGNITION TERMINAL SLEEVE

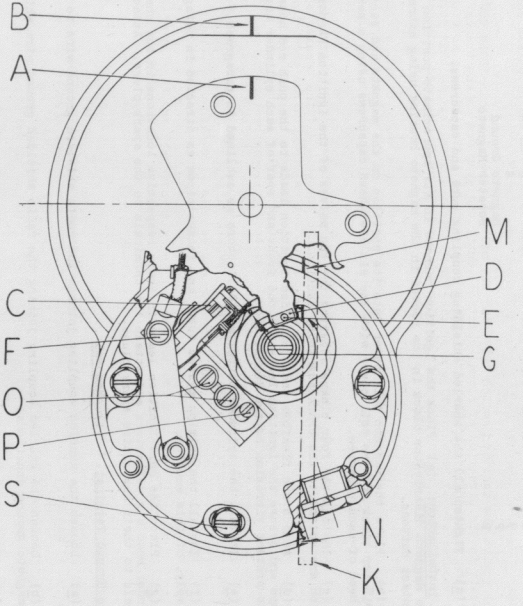

FIG. 18- SKETCH FOR MAGNETO TIMING

(4) Remove the breaker housing cover which exposes the cam and pivotless contact breakers in the housing.

(5) With the ignition switch "OFF" and the mixture control set in "IDLE CUT-OFF" turn the engine crankshaft in the direction of normal rotation, until the step cut in the breaker cam "L" lines up with the timing marks "M" cut in the rim of the breaker cup, as indicated by a straight edge "E" (preferable a steel scale). Refer to Figure No. 18 for designated details. At this point the timing mark "A" on the distributor rotor will coincide with the mark "B" on the magneto front end plate indicating that the rotor is in a position to distribute a spark to No. 1 cylinder.

(6) The following procedure is recommended in removing a magneto in the event that the timing hole plug in the crankcase front section is not accessible. If the timing inspection hole in the crankcase front section is accessible, the procedure outlined in paragraph (7) below is the easiest and preferred method.

(a) Insert a piece of .001" steel feeler stock between the contact point "C" by lifting the felt covered cam follower "F" which causes the points to open. If the breaker spring itself is lifted to insert the feeler between the points, a permanent set may result from excessive bending. If the points have already begun to open, insert the feeler stock and turn the engine crankshaft slightly in the direction opposite normal rotation or continue with the rotating in the normal direction of rotation until the breaker points are closed with the felt-lined follower resting on the flat of the cam preceding the lobe which opens the breaker points to furnish No. 1 cylinder with its firing spark. Now turn the engine slowly in the direction of normal rotation and pull lightly on the feeler stock. Stop turning the crankshaft at the instant the feeler stock starts to slip, indicating that the breaker points are opening. Remove the cotterpins, castellated nuts and washers from each of the three magneto attaching studs holding the magneto to keep it from dropping due to its overhanging construction.

CAUTION: Do not disturb the engine crankshaft setting thus obtained until the replacement magneto has been installed.

(7) If the timing inspection hole in the crankcase front section is accessible for installing the replacement magneto, the inoperative magneto may be removed as soon as its timing marks have been aligned according to paragraph (5), above. Remove the magneto as previously described.

b. Installation. - (1) Remove the coil cover distributor block and breaker cover, if installed, from the replacement magneto. Scintilla pivotless type contact breakers used in this series magneto must always be adjusted so that the contacts open at the proper position of the breaker cam in relation to the timing marks on the rim of the breaker cup and not for any fixed clearance between contacts. Before installing the replacement magneto, first check the adjustment of the breaker contacts as follows:

(a) Lift the cam follower "F" and wipe the contact points with a clean cloth moistened with unleaded gasoline. Do not allow gasoline to come in contact with the felt covered follower as this would thin the oil in it.

(b) Turn the magneto drive shaft in the direction of normal rotation until the step cut in the breaker cam "L" lines up with the timing marks "M" cut in the rim of the breaker cup as indicated by a straight edge "K" (preferably a steel scale). Refer to Figure No. 18. At this point the timing mark "A" on the distributor rotor will coincide with the mark "B" on the front end plate, indicating that the rotor is in a position to distribute a spark to No. 1 cylinder.

(c) Insert a piece of .001" feeler stock between the contact points "C" by lifting the felt covered cam follower "F" which causes the points to open. Do not lift the breaker spring to insert the feeler. Turn the engine crankshaft until the breaker points open as indicated by the feeler stock slipping. Stop turning the crankshaft at the instant the feeler stock starts to slip. Place the straight edge against the face of the step cut in the cam and check the alignment with the timing marks "M" in the rim of the breaker cup.

(d) If the straight edge does not coincide with the timing marks, turn the magneto shaft until the alignment is made keeping the .001" feeler stock between the points. Loosen the two screws "O" which fasten the breaker assembly to the breaker housing. Hold the magneto shaft in the aligned position and adjust the eccentric "P" so that the contact points are just beginning to open. Tighten the retaining screws "O" and recheck the adjustment.

(2) With the adjustment thus obtained the poles of the rotating magneto are in a position where the maximum energy has been stored in the magnetic circuit when the breaker points open to cause a high-tension spark to be delivered to the spark plug.

(3) If the timing plug on the left-hand side of the crankcase front section is accessible, break the safety wire and remove the plug with its copper-asbestos gasket. If the crankshaft has not been disturbed since the magneto was removed, following the procedure given in paragraph a, above, the piston in No. 1 cylinder should be near the top of its compression stroke. Looking through the timing inspection hole a crank angle degree scale ranging from 0° to 35° before top center on No. 1 piston is seen etched on the rim of the reduction driving gear. Move the propeller until the line scribed on the rear of the timing inspection hole indicates that the No. 1 piston is located at the crank angle degrees before top center corresponding to the spark timing value stamped on the engine data plate for the magneto being installed.

(4) In the event that the timing plug hole in the crankcase front section is not accessible, the crankshaft setting obtained prior to the magneto removal as described in paragraph a (6), above, should be used for the installation of the replacement magneto.

(5) Apply a heavy grade of petrolatum to the splines of the magneto drive shaft coupling. With the distributor rotor held in the position to fire No. 1 cylinder as obtained in paragraph b. above, install the magneto on the supercharger housing rear cover mounting pad. Having the splined magneto coupling inserted into the mating splined end of the engine magneto drive gear, move the magneto to its extreme positions allowed by the slots in the mounting flange noting if the breaker points open and close. If the breaker points open and close, assemble a flat washer and a castellated nut on each of the three attaching studs sufficiently tight to hold the magneto firmly on the cover but not tight enough to prevent adjusting the position of the magneto.

(6) If the points do not open and close when moving the magneto from side to side, withdraw it from the engine. Install the magneto coupling wrench over the splined drive shaft coupling to keep the shaft stationary, and remove the cotterpin, castellated nut, and washer which retain the coupling on the shaft. The coupling, which is fitted to the shaft by six slots on its inside diameter, should be withdrawn, turned to the next slot engaging position, and reinstalled on the shaft. Install the retaining washer and nut and check the opening and closing of breaker points with the magneto on the engine. When the results are satisfactory, withdraw the magneto to install the cotterpin in the coupling retaining nut, and reinstall the magneto on the engine as directed in paragraph (5) above. All adjustments must be made at the drive end of the magneto by changing the location of the coupling splines and not by altering the breaker point opening adjustment.

(7) Move the magneto in the direction opposite to crankshaft rotation until the breaker points open and insert a strip of .001" steel feeler stock between them. Move the magneto as far as it will go in the direction of crankshaft rotation so that the breaker points have closed on the feeler stock. Tap the magneto slowly back in the other direction and pull lightly on the feeler stock until it starts to slip, indicating that the breaker points are just beginning to open. Tighten the three flange attaching nuts to secure the magneto at this location.

(8) Check the setting by turning the propeller backward about a quarter of a revolution and reinstalling the strip of .001" feeler stock between the breaker points. Tap the propeller forward slowly, stopping when the feeler strip is released from the breaker points. The crank angle degree reading observed on the rim of the reduction driving gear through the crankcase front section timing plug hole should correspond to the engine data plate spark advance at the instant the feeler strip is released. Install the cotterpins in the magneto flange attaching nuts when the correct spark advance setting has been established.

(9) Install the plug in the timing inspection hole in the crankcase front section with the copper-asbestos gasket under its head. Tighten and safety wire.

(10) Install the breaker housing cover and tighten the two hex-head capscrews which are retained in the cover by circlets. Check the capscrews for a lockwasher under the head of each.

(11) Reinstall the distributor block, coil cover, radio shielding and ground terminal as described in paragraph 10 of this section.

12. Starter Replacement

a. The starter is secured to the supercharger rear housing cover mounting pad by six studs, washers, nuts and palnuts.

b. For complete information regarding the replacement, wiring and installation of aircraft engine starters refer to the applicable Technical Order for the particular starter. (Refer to Index, T. O. No. 00-1).

13. Generator Replacement

a. The generator is secured to its mount pad in the supercharger rear housing cover directly below the starter by six studs, plain washers, nuts and palnuts.

b. When replacing the generator, refer to the applicable Technical Order to obtain instructions on the installation, wiring, etc., and complete information pertinent to the type of generator being removed or installed. (Refer to Index, T. O. No. 00-1).

14. Fuel Pump Replacement

a. The fuel pump is mounted on the right-hand side of the supercharger rear housing, slightly below its mid-section. It is secured by four equally spaced studs, plain washers, nuts and lockwire.

b. When removing or replacing the fuel pump, refer to the applicable Technical Order for the fuel pump to obtain specific information pertinent to the type of fuel pump being removed or installed. (Refer to Index, T. O. No. 00-1).

15. Fuel Pump Drive Shaft and Oil Seal Replacement

a. Disassembly. - (1) With the fuel pump removed from its mount pad, insert the two puller screws and remove the fuel pump drive shaft and support assembly as one unit.

(2) Insert a small diameter fibre drift in the outer end of the support and drive out the fuel pump drive shaft from its supporting bushings.

b. Oil Seal Replacement. - (1) The fuel pump drive shaft oil seal assembly consists of a steel cup in which is assembled a leather seal reinforced by a coiled type spring. This assembly is replaced as one unit and cannot be disassembled.

(2) Remove the oil seal by inserting a drift in the inner end of the support and drive out the oil seal.

(3) Replacement of the oil seal is accomplished by pressing the new seal into its recess in the drive shaft support until the spring side of the seal bottoms in the recess.

c. Assembly. - (1) Insert the drive shaft into the support with the gear end of the shaft towards the inner end of the support. Tap the gear into place until the shoulder at the inner end seats against the flange of the rear supporting bushing.

(2) Insert the support and drive shaft assembly into the supercharger rear housing, rocking it slightly to insure proper meshing of the gears. A new gasket should be installed under the flange of the support.

(3) Install the fuel pump as directed in paragraph 14 of this section.

16. Dual Accessory Drive Assembly

a. Accessory Replacement. - (1) Provision for two optional small accessories is made possible by the use of a spur gear box attached to the supercharger rear housing cover at the spare drive mounting pad. An accessory is secured to the attaching studs of the upper drive by plain washers, nuts and palnuts. Similar practice is employed on the larger lower drive mounting pad, retaining the accessory with nuts and palnuts on the attaching studs.

(2) When removing or installing an accessory on the dual accessory drive, refer to the Technical Order applicable to the accessory. (Refer to Index, T. O. No. 00-1).

b. Dual Accessory Drive Disassembly and Removal. - (1) Make sure the dual accessory drive housing is accessible by removing all lines from the accessories driven by that unit. Remove the palnuts, nuts and washers from the attaching studs on each of the two mounting pads and withdraw the accessories or cover plates with their gaskets. Remove the loose fitting tongue drive adapters where utilized in the splined drive shafts. Break the safety-wire and remove the special cap nuts and washers from the two studs extending from the supercharger rear housing cover through the upper left-hand side of the dual accessory drive housing. Remove the palnut, nut and washer from the one remaining attaching stud on the right-hand side of the cover adjacent to the lower drive mounting pad.

(2) Remove the dual accessory drive cover and gasket by tapping on its sides with a rawhide mallet, being careful not to allow the spur gears to drop out of their bushings in the housing. Withdraw the upper and lower gears, after which the two intermediate gears may be removed, exposing the nuts holding the dual accessory drive housing to the supercharger rear housing cover.

(3) Remove the castellated nuts and washers from the two studs extending from the supercharger rear housing cover through the central portion of the accessory drive housing wall section. Break the safety-wire and remove the shouldered nuts and washers, located at the corners of the housing, using an offset box-socket wrench and handle. (Refer to T. O. No. 02-35-3). Remove the acorn nuts and copper washers from the studs which extend from the bottom of the accessory drive housing through the supercharger rear housing and cover parting flanges. Remove the dual accessory drive housing and gasket from the supercharger rear housing cover by tapping with a rawhide mallet.

c. Dual Accessory Drive Speed Ratio Change. - (1) To change the speed ratio of the accessory drives to the crankshaft, it is necessary to replace the two gears in primary gear train (identified by their large teeth) with two gears of the desired ratio. The primary gear train consists of the drive gear machined integral with a splined shaft, and the intermediate gear which is bolted to the driving gear of the secondary train (identified by their small teeth).

(2) Six capscrews are employed to retain the intermediate gears together. The drilled heads are safety-wired together and do not require washers.

d. Dual Accessory Drive Installation. - Prepare the supercharger rear housing cover to receive the dual accessory drive unit as follows:

(1) Remove the two pipe plugs from the lower left-hand corner of the dual accessory drive mounting pad on the supercharger rear housing cover, thus uncovering holes for the dual accessory drive gear lubrication oil to drain into the supercharger rear housing. Remove the two flat head bolts extending through the supercharger rear housing and cover parting flanges at the lower right-hand corner of

the dual accessory drive mounting pad. Remove the palnuts and nuts from two supercharger rear housing cover attaching studs immediately above the countersunk flat head bolt holes and from the adjacent attaching stud at the left of the countersunk holes. Remove the palnuts and nuts from the four studs holding the cover plate over the spare accessory drive shaft and withdraw the cover plate and gasket. Place a dual accessory drive mounting pad gasket over the studs now exposed.

(2) Make sure the pipe plug has been removed from the tapped drain hole in the lower corner of the dual accessory drive housing. Place the housing in position on its attaching studs but do not push it all the way on to its mounting pad until the nuts are started on the studs under the overhanging parting flange. The three supercharger rear housing cover attaching studs at the outer corners of the accessory drive housing utilize plain washers and special shouldered nuts requiring the use of an offset box-socket wrench and handle. The two studs extending from the supercharger rear housing cover through the central part of the accessory drive housing employ plain washers and castellated nuts. The castellated nut in the center of the housing is cotterpinned and the other four nuts are safety-wired. Install copper washers and acorn nuts on the two studs which extend from the bottom of the accessory drive housing through the countersunk holes in the supercharger rear housing cover, and safety-wire the drilled tips of the acorn nuts together.

(3) Oil the four bushings in the accessory drive housing with engine oil. Place the primary drive gear (large teeth) in mesh with its intermediate gear and insert the two gears together into their supporting bushings in the accessory drive housing. The upper and lower accessory drive gears may then be placed in the housing, taking care to have the gear with involute splines and short front journal in the upper blind bushing and the gear with square splines and long front journal in the lower open bushing. Timing marks are not necessary on any of the spur gears making up the dual accessory drive.

(4) Install a gasket on the dual accessory drive housing parting surface and smear the gears with engine oil. Place the cover on its attaching studs and slide it forward over the rear journals of the gears. Place a plain washer and special cap nut on each of the two studs extending from the supercharger rear housing cover through the upper lef-hand side of the accessory drive housing. Similarly install a plain washer and plain nut on the cover attaching stud located between the upper and lower drives. Tighten these nuts evenly, safety-wiring the two special nuts together and installing a palnut over the plain nut. Refer to T. O. No. 02-1-10 on use of lock-nuts.

(5) Install gaskets and accessories or cover plates on the two mounting pads following the instructions in applicable Technical Orders. Secure the accessories or cover plates with plain washers, nuts, and palnuts.

17. Tachometer and Oil Pump

a. General. - The oil pump and tachometer assembly is located on the supercharger rear housing cover at the lower left-hand side. A mounting pad for an electric type tachometer and a screw-type connection for a mechanical type tachometer is provided at the rear of the pump to the right of the oil pressure relief valve.

b. Oil Pressure Relief Valve Adjustment. - Break the safety-wire and remove the cadmium plated steel cap and gasket from the oil pressure relief valve assembly located on the rear of the oil pump adjacent to the end plate. Loosen the large locknut on the slotted adjusting screw to permit movement of the screw in either direction. Screwing in the clockwire direction increases the relief valve spring tension and engine oil pressure, and the opposite result is obtained by an anti-clockwise movement of the adjusting screw. When the desired engine oil pressure has been obtained, tighten the locknut against its shouldered copper gasket. Reinstall the steel cap and its shouldered copper gasket.

c Oil Pressure Relief Valve Replacement. - (1) Remove the oil pressure relief valve steel cap and locknut with their shouldered copper gaskets as described in paragraph 17 b above. Unscrew the slotted adjusting screw all the way off the bronze relief valve body, being careful not to accidentally lose the coiled spring which is immediately behind the adjusting screw. Remove this coiled spring and withdraw the steel piston from the bore of the bronze relief valve body.

(2) The relief valve body may be unscrewed from the aluminum alloy oil pump body by inserting the lugs of the wrench specified in T. O. No. 02-35-3 into the slots on the rear end of the relief valve body. Installation of a replacement bronze body is accomplished with the same tool.

(3) To assemble the unit, insert the hollow piston type valve into the bronze relief valve body and place the coiled spring inside the piston. Screw the adjusting screw in approximately 1/3 of its length on the outside diamter of the bronze body over the extended end of the coiled spring. Install the locknut and its shouldered copper gasket loosely on the adjusting screw. Set the adjusting screw to give the desired engine oil pressure, tighten the locknut, and install the steel cap and its gasket according to instructions in paragraph 17 b above, of this section.

d. Oil Inlet Check Valve Replacement. - (1) Break the safety-wire and remove the cadmium plated retainer from the left-hand side of the oil pump. Remove the copper-asbestos gasket, spring, and hollow piston from the bore of the bronze valve body.

(2) The bronze valve body is pressed into the oil pump body and cannot be removed in the field. The steel piston employs one piston ring and may be replaced without the use of special tools. Expand the ring slightly and slide it over the chamfered end of the piston dome and into the piston ring groove. Refer to T. O. No. 02-35-1 for correct ring clearances and spring tension.

(3) Assembly is accomplished by inserting the piston and ring into the bronze check valve body, compressing the ring to permit entrance. Insert the spring into the hollow piston and screw on the retainer having a new gasket under the flange. Tighten and safety-wire the retainer to prevent its loosening.

(4) R-1820-87 engines are not equipped with oil pump check valves.

e. Oil Pump Removal. - (1) Unscrew the temperature bulbs from the inlet and outlet chambers of the oil pump. Remove the oil inlet and outlet oil lines and remove the tachometer connections.

(2) Break the safety-wire and remove the special shouldered capscrew from the attaching leg at the right of the oil pump. Break the safety-wire and remove the nuts and washers from the eight long attaching studs and remove the pump. Support the pump to prevent separation of the covers and housings. Temporarily retain the housings and covers by installing two long bolts of the same diameter as the mount studs.

f. Oil Pump Installation. - (1) Place a new gasket over the long oil pump attaching studs, making sure the oil holes line up correctly. Coat the oil pump drive shaft coupling with a petrolatum, Spec. AN-VV-P-236, and install the pump over the attaching studs, meshing the coupling with the splined end of the drive shaft in the supercharger rear housing cover. Install the plain washers and castellated nuts on the attaching studs. Tighten and safety-wire the nuts together. Place a plain washer under the head of the special shouldered capscrew which secures the attaching leg of the oil pump to the supercharger rear housing cover. Safety-wire the capscrew.

(2) Reinstall the tachometer cables, oil lines, and temperature bulbs on the pump.

(3) If it is found necessary to readjust the oil pressure relief valve to obtain the desired pressure, remove the steel cap from the valve body, loosen the locknut, and, turn the adjusting screw clockwise to increase the pressure. The pressure regulation should be accomplished with the oil inlet temperature at the normal value. Refer to T. O. No. 02-35GC-1. Tighten the locknut and reinstall the steel cap. Insure that the shouldered washer is installed under the cap.

18. Cuno Automatic Filter Replacement

a. The Cuno Automatic filter is attached to the left-hand side of the supercharger rear housing slightly below its mid-section.

b. Removal of the filter is accomplished by breaking the lockwire and removing the three shouldered attaching capscrews. It may be necessary to tap the filter lightly with a rawhide mallet to effect removal if the filter is stuck.

c. Removing the extended capnut on the outer face of the filter head exposes a pinion shaft which is provided to turn the filter manually for test or inspection purposes. Reverse the capnut and screw it on the end of the pinion shaft thus providing a means of turning the filter.

d. Reinstall the capnut in its original position on the pinion shaft bushing and lockwire. Insert the filter in its recess in the supercharger rear housing, with its inner end fitting snugly in the supporting boss at the center of the supercharger rear housing cover. Make sure a new gasket is installed under the head of the filter. Insert the three retaining capscrews, tighten, and lockwire together.

19. Supercharger Drain Valve

a. Standard Type. - (1) Removal

(a) Disconnect the drain line from the outlet connection of the supercharger drain valve, located on the lower right-hand side of the supercharger rear housing. Remove the drain valve assembly by unscrewing the steel body out of the shouldered bronze bushing in the supercharger rear housing. This steel body is provided with hexagonal flats on its shank to accommodate an open end wrench.

(2) Installation: (a) Insert the drain tube into its passage in the lower right-hand side of the supercharger rear housing where it is retained by screwing the steel body into the shouldered bronze bushing, using the hex flats milled in the shank of the body. Swing the aluminum alloy drain valve housing into the desired position for attaching the drain line, and secure it by tightening and safety-wiring the drain valve retaining plug. Connect the drain line to the outlet nipple in the aluminum alloy drain valve housing.

b. Turbo Type. - (1) Removal

(a) Disconnect the drain line from the outlet connection in the drain valve housing. Break the lock wire securing the valve housing to the supercharger rear housing, and unscrew the valve housing from the valve body. Take care not to drop the piston and disc unit which may remain either with the valve body or in the valve housing. Remove the piston and disc unit. Using the special wrench, unscrew the valve body from the supercharger rear housing, and withdraw the body and tube assembly as a unit.

(2) Installation: (a) Install two new rubber packing rings in the groove at the small end of the valve body, and one below the flange at the large end of the valve body. If the drain valve is not assembled, place the piston and disc unit on the valve body. Assemble the housing to the valve body.

(b) Insert the complete assembly in the supercharger rear housing, using a washer between the flange on the valve body and the supercharger rear housing. Lockwire the drain valve housing to the supercharger rear housing, and install the drain line in the valve housing outlet.

20. Supercharger Oil Seal Vent

a. At the forward end of the supercharger rear housing adjacent to the carburetor adapter, is located the supercharger oil seal atmosphere vent fitting. This fitting consists of a hollow hex head steel plug having breather holes drilled under the head and a fine mesh brass screen over the bottom of the pipe threaded shank. Outwardly it resembles a large cap bolt screwed part of its length into the supercharger rear housing.

b. This vent fitting may be removed from the supercharger rear housing for cleaning or replacement. Use compound, thread, Spec. No. 3590, on the threads when reinstalling, being careful not to clog the fine brass screen on the inner end.

21. Gun Synchronizers

a. Impulse generators for two guns synchronized to fire through the propeller are mounted, one on each side of the supercharger rear housing, with the exception of the model R-1820-97 engine, on which only the right hand impulse generator is mounted. The installation of an external propeller governor oil supply line on the R-1820-97 engine replaces the left hand gun synchronizer impulse generator drive. Some model R-1820-65 engines also incorporate this external propeller governor oil supply line. Each impulse generator drive shaft is driven at propeller speed through spiral gear teeth on the inner end which mesh at right angles with teeth cut in the shank of each magneto drive shaft.

b. The three capscrews and plain washers, which secure the dummy synchronizers with which the engine is shipped, are also used to secure the impulse generators and drive shaft supports.

c. Deleted by revision dated 12-10-42.

22. Propeller Governor Replacement

a. The propeller governor is mounted on a propeller governor adapter on the crankcase front section, employing an oil resisting gasket on the governor mounting pad. Four run-fit attaching studs are used which bottom in blind bushings inserted in the propeller governor adapter. Plain washers, castellated nuts, and lockwire are used to secure the governor to the attaching studs.

b. When installing or replacing the propeller governor, refer to T. O. No. 03-20CA-2 to obtain specific information. A wrench or stud driver should not be used when installing the run-fit attaching studs. Screw each stud, with the fingers only, until its top bottoms in the blind receiving bushing.

SECTION IX

ACCESSORIES

1. Carburetor

a. For complete information concerning the description, installation, inspection and maintenance of the Bendix-Stromberg Injection carburetors with which these engines are equipped, refer to T. O. No. 03-10BA-2.

b. Operating instructions for engines equipped with Bendix-Stromberg Injection carburetors may be found in T. O. No. 02-35GC-1 and T. O. No. 02-1-29.

2. Magnetos

For complete information covering the Scintilla SF-9L-4 magnetos with which these engines are equipped, refer to T. O. No. 03-5DA-2, supplemented by instructions previously given in this Handbook.

3. Radio Shielding

For general information concerning radio shielding, refer to T. O. No. 08-5-1 supplemented by instructions previously given in this Handbook.

4. Spark Plugs

The R-1820-65, -73 and -97 engines are equipped with either Aero LS38C or Champion C34S spark plugs, the R-1820-71 engines with BG-298GS spark plugs, and the R-1820-87 engines with Champion C34S or A.C. LS85 spark plugs. Complete information on these spark plugs may be found in T. O. No. 03-5E-1 supplemented by instructions previously given in this Handbook.

5. Oil Filter

In addition to the instructions previously given in this Handbook concerning Cuno Automatic oil filters, refer to T. O. No. 02-1-24.